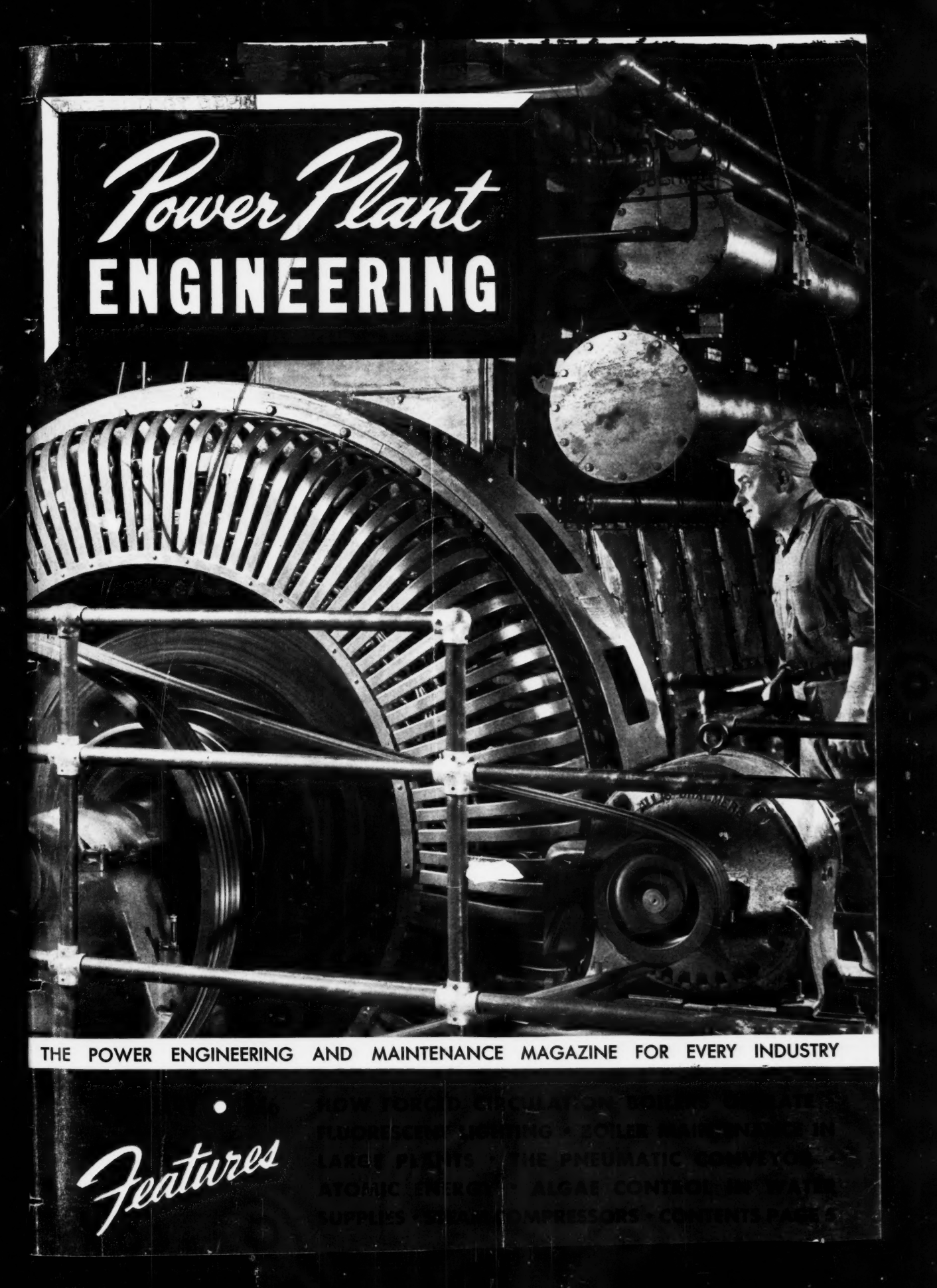
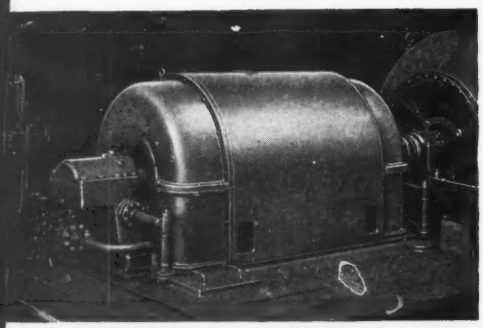

Power Plant
ENGINEERING
THE POWER ENGINEERING AND MAINTENANCE MAGAZINE FOR EVERY INDUSTRY
Features

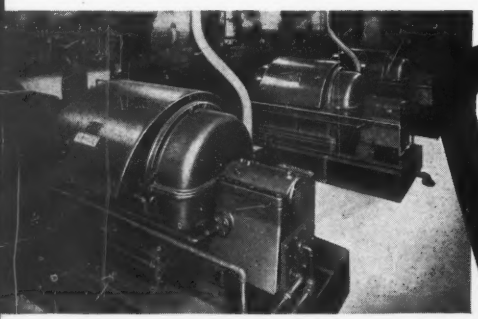
R v. 50 Jan.-June 1946

They've got

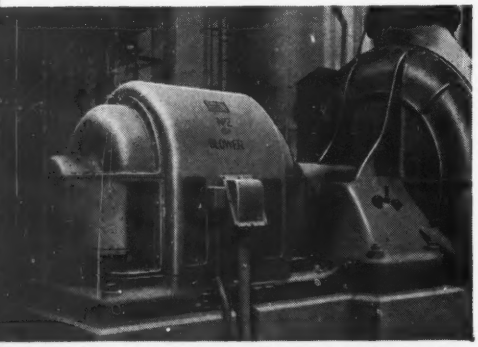
THOSE BIG TWO-POLE MOTORS by ELLIOTT



Elliott 2500-hp two-pole squirrel-cage induction motor driving a blower for installation in a metal refining plant. The motor is enclosed, self-ventilated with air cooler, lubricated from an integral lubricating system.



Three Elliott 1750-hp two-pole induction motors of drip-proof construction driving high-pressure boiler-feed pumps in a central station.



Elliott 350-hp two-pole splash-proof induction motor driving Elliott blower in an oil refinery.

TYPICAL REFINEMENTS

- Smooth, streamlined appearance—
- Substantial cast iron frames and brackets—quiet, stiff, vibrationless—
- Rotor bearings rigidly braced from base—
- Rotor carefully balanced dynamically and statically—
- Silver soldered joints assuring permanent connections.
- Rotor winding designed for the service required. Elliott "diamond cage" construction used where exceptional strength is needed.
- Substantial, roomy conduit box—
- Construction minimizes windage and magnetic noises—
- Controlled ventilation assures cool operation—

Tech

ELLIOTT Company

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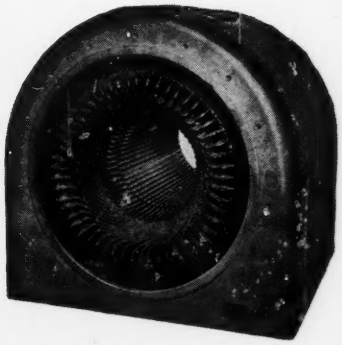
what it takes-

When you've specialized along certain lines for thirty-five years, you are more than likely to excel at it. That has been Elliott Company's case in the matter of these large, high-speed two-pole motors.

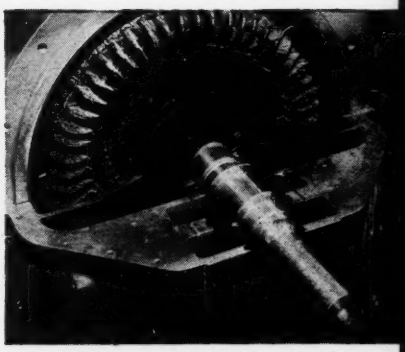
Elliott engineers have never stopped improving the qualities of motors in that class and new refinements, new ways of construction have tended to make almost any large high-speed motor drive a job for Elliott.

Consult Elliott motor engineers on your next large motor requirement.

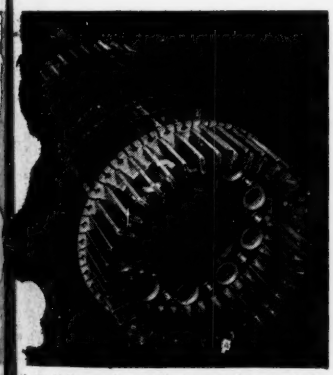
Silver soldering assures permanent connections on all Elliott motors.



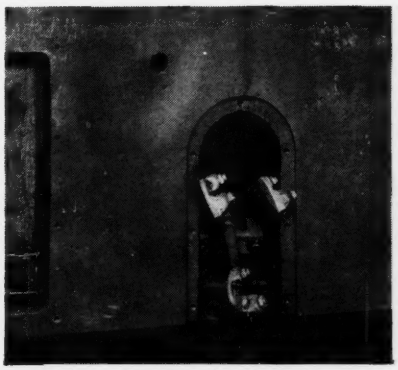
Elliott motors have a rugged cast iron frame which is also smooth and streamlined.



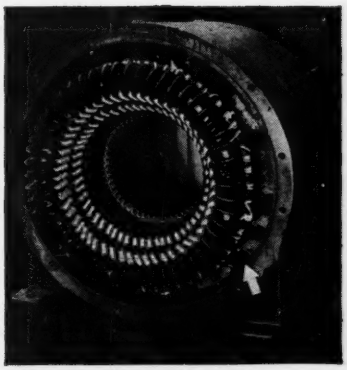
Substantial cast iron brackets help make Elliott motors quiet and vibrationless.



Elliott "diamond cage" construction used for special torque and/or current characteristics.



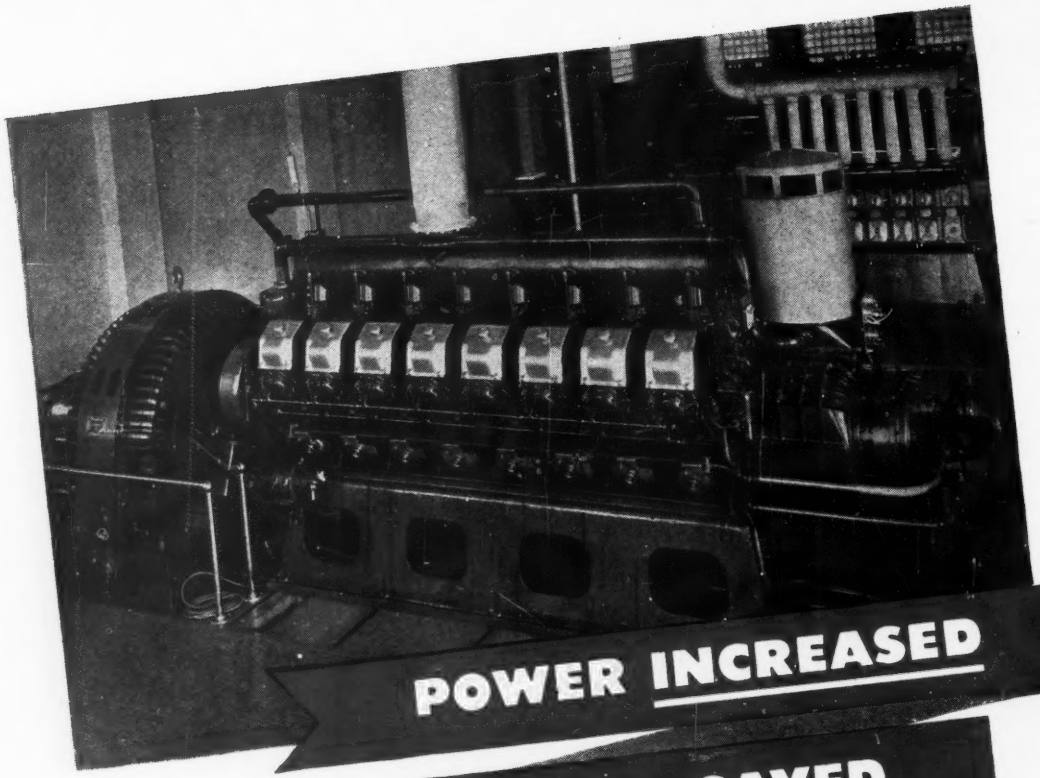
A substantial, roomy conduit box is a feature of all Elliott motors.



The arrow points to ventilating ducts and coil bracing similar to that used on Elliott turbo-alternators.

L-764

STEAM TURBINES • GAS TURBINES • ELECTRIC GENERATORS AND MOTORS • BLOWERS AND COMPRESSORS • TURBOCHARGERS FOR DIESEL ENGINES • CONDENSERS • STEAM JET EJECTORS • FILTERS • FEEDWATER HEATERS AND DEAERATORS • DESUPERHEATERS • TUBE CLEANERS • GREASE EXTRACTORS • SEPARATORS • STRAINERS • NONRETURN VALVES



POWER INCREASED

FUEL SAVED

MAINTENANCE REDUCED

with

EFFECTIVE DIESEL LUBRICATION

TEXACO *Ursa Oils* do more than just an outstanding job of lubricating—*they keep Diesel engines clean!* This means they prevent varnish and sludge. Rings stay free and valves active. Pistons provide proper seal for full compression. *Ursa Oils* also prevent scuffing, greatly reduce wear, and have special properties to prolong the life of bearings, liners, rings and pistons. You can depend on trouble-free operation, lower maintenance costs.

The Texas Company, in step with improvements in Diesel engine design over the past thirty years, has developed *a complete line* of *Texaco Ursa Oils* . . . one to meet the requirements of every type and size of Diesel.

On the basis of *performance*—all leading Diesel engine manufacturers approve *Texaco Ursa Oils,* and—

More stationary Diesel hp. in the U. S. is lubricated with Texaco than with any other brand.

Let Texaco Lubrication Engineering Service help you obtain the most efficient and economical operation from *your* Diesels. Just contact the nearest of more than 2300 Texaco distributing plants in the 48 States, or write: The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO REG. T.M.

TEXACO Ursa Oils

FOR ALL DIESEL ENGINES

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Power Plant ENGINEERING

January 1946

VOLUME 50—NUMBER 1

Cover: Diesel engine in midwest stone quarry drives 700 kw a-c generator to power the plant's many crushing and screening operations. Photo, Allis-Chalmers Mfg. Co.

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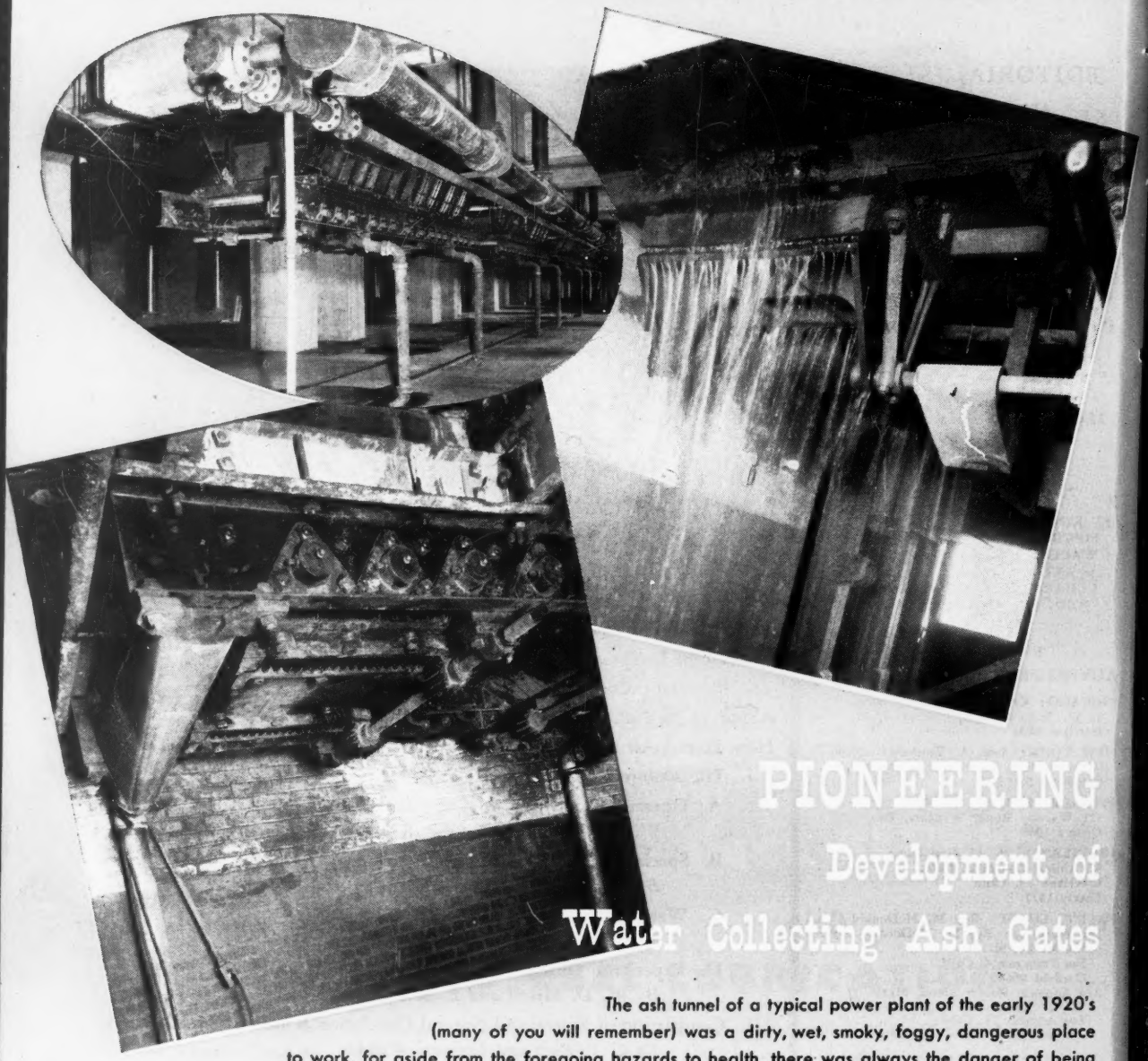


PIONEERING

Development of Water Collecting Ash Gates

The ash tunnel of a typical power plant of the early 1920's (many of you will remember) was a dirty, wet, smoky, foggy, dangerous place to work, for aside from the foregoing hazards to health, there was always the danger of being struck by falling clinkers, or carbon monoxide gassing. Average conditions of those days are accurately depicted by the photo in the upper right, while the photo in the lower left shows the A-S-H Type "C" Water Collecting Ash Gate, which was installed in place of the one in the upper right. Note total absence of leaking water and, while not shown pictorially, all the other unhealthy dangerous conditions were also eliminated.

Perfection of an ash gate that really collected 100% of the water, 100% of the time was not easy, but with the cooperation and confidence of designing engineers of those days (many whose names are well known to most of you these days) we succeeded. Though they must remain anonymous in this advertisement, they know, and we thank them.

With the Type "C" Gate, a small sectional plate cast iron ash hopper, externally bolted to a steel framework, replaced the former heavy slab type construction. This led to our development of a design of Locktile, which permitted the replacement of a single tile, without disturbing the rest of the hopper lining. A modern installation of hoppers and gates is shown in the oval illustration.

If your ash tonnages do not warrant a Hydrojet System, A-S-H Hoppers and Gates are your best bet. Hundreds of installations prove it. Catalog on request.

AS ALWAYS (N) *WILL PIONEER IN ASH AND DUST REMOVAL*

ALLEN-SHERMAN-HOFF CO., 233 S. 15th St., PHILADELPHIA 2, PA. *Offices & Representatives in Principal Cities*

Front Lines

YOU MAY HAVE fuel supply difficulties this winter and then again you may not. In any case, to save both fuel and money, you'll do well to check up on steam traps in your heating system. Some pertinent pointers on unit trapping, installation, venting and preventive maintenance, given in the Armstrong Trap Magazine, No. 4, 1945, should help you in making your check-up.

EVERYBODY has heard the comment that during this war "electric power was never too little or too late" or the other comment by one of the admirals in charge of Navy production to the effect that "when we asked for power, we got power and not excuses". But just how was it done? During the war it was not possible, of course, to give details about specific procedures. A very good idea of the overall power pooling set-up that was one of the principal factors, although by no means the only factor, was discussed in considerable detail in the October issue by Edward Falck, former head of OWU. But a typical case, with all the details, showing all the expedients and the engineering shortcuts and the team work of the personnel at all levels and the way in which equipment was used and how they used what they could get and just how fast they worked and so on—those are the things engineers wanted to know. Well, much of that type of information is given in an article, in the December issue of Contact, entitled how Victory was Built at Newport. This is the story of how New England Power Co. supplied the power necessary for the construction and operation of the great Naval bases at Newport, R. I. Of particular interest are the pictures.

C. W. DeFOREST, who resigned this year from the vice-presidency of Columbia Gas & Electric systems and associated organizations, has been selected as the new head of the German utilities under the Allied Control Authority. He replaces Col. Walker R. Cisler who is returning to this country, after more than two years of service in the administration of utility system in Europe, to resume his post as chief engineer of power plants of the Detroit Edison Co. As noted in Front Lines, September, 1945, Mr. DeForest was head of the Utilities Subcommittee of the Technical Industrial Intelligence Committee that was sent into Europe last spring to study especially the technical developments of German industry. In his new capacity, Mr. DeForest will be chairman of a board representing all four occupying powers, which confers on all utility problems in the various zones of occupation. The particular job of the American Utility Section is to co-ordinate utility operations in the American zone with those in the other zones, so that the various hydro-electric and steam systems will aid in operating the country as an economic unit.

VACUUM of one-millionth of a millimeter (10—6mm) of mercury was required for certain war-production, including some of the atom-bomb production processes, as described elsewhere in this issue. To produce such vacuums, rotary pumps capable of producing one hundredth of a millimeter, as often used in industrial processes, could not do this job alone. So Westinghouse engineers, who were called on to supply these high-vacuum pumps in large sizes, large quantities and a short time, utilized the diffusion principle, previously used only in laboratory and very special industrial work. The resulting pump consists of a vacuum-tight cylinder with water-cooling coils on the outside and, inside the cylinder, a jet assembly of one or more jets in series. A pool of oil at the base of the cylinder is heated and the oil vapor passes up through a central pipe in the jet assembly. On reaching the top, the vapor is deflected downward by the jet in the form of a cone-shaped spray against the wall of the cylinder. This cone of downward moving oil vapor traps and carries out the gas molecules from the region above. The oil vapor is condensed by the water-cooled wall of the outer cylinder and is used over again. The gas has now become concentrated enough so that it can be pumped off by a good rotary pump. Rotary pumps and diffusion pumps are used in series, the rotary pumps doing the large-volume coarse-vacuum portion of the job, while the diffusion pumps carry the vacuum on down to the desired low value.

A NEW DRUM opening tool that cuts away the top of metal containers and folds the edges evenly, close to the barrel rim, is reported by Oakite News Service. It eliminates tedious cutting with chisels or hammers.

HOW HEAT FLOWS through a turbine blade, the shocks to a vacuum-tube grid when a crate of tubes is dropped, the torques developed in a generator shaft during short circuit, and complicated problems in hydraulics—all nearly impossible of solution by mathematics—can now be solved in a few hours or days by an electrical analyzer developed by Westinghouse. The great diversity of problems that can be solved electrically is a manifestation of the orderliness of nature. The worlds of mechanics, thermodynamice, hydraulics, and electricity are each goverened by their own sets of laws. But the laws in one field are analogous to those in another. The mechanical transients analyzer is built on these analogous behaviors. The time saved is astounding. In the first six months that the mechanical transients analyzer has been in use, the number of problems solved that could have been done by conventional mathematical analysis would have required two mathematicians working for a period of at least fifteen years. In addition, several important problems have been analyzed that could not have been handled by conventional mathematics.

THE PROBLEM of finding suitable methods for reducing the attack of chemical reagents heretofore never encountered in the petroleum, chemical and other fields was hastened by the introduction of new processes during the war. To make matters more difficult, wartime restrictions made imperative the adaptation, so far as possible, of existing equipment to new processes. One of the techniques used in adapting such existing equipment was to equip it with corrosion resistant linings. How these linings are designed and the details of how they can be applied to equipment in the shop or in the field are given in a well-illustrated article in Inco, Vol. 20, No. 1. Use of a thin lining bonded to a steel base plate or of a separate loose liner attached at regular intervals to the steel vessel are the two most practical methods in wide-spread use. Liner metals of Monel, nickel and Inconel are discussed, also heat transfer requirements, methods of welding and testing welds. Lining of nozzle necks and facing of flanges requires a different technique, which is fully described.

RAPID INCREASE in horsepower available from aircraft engines is graphically displayed by the history of the dynamometers used to test them. It is customary for engine builders when purchasing dynamometers to order them twice as large in horsepower rating as the largest engine available at this time. This allows for future growth in engine capacities. With the exception of two 4000-hp dynamometers, at the war's beginning most of them were capable of absorbing about 2000 hp. The newest one, well under way at the East Pittsburgh Works of Westinghouse, will be good for 7700 hp. Instead of the usual weight scale to measure torque, pneumatic indicators are used in which torque is measured by air pressure.

RECENT news columns have carried many stories concerning the important role played by Geiger-Müller tubes in surveying atom bomb areas for possible dangerous after effects. Engineers of North American Philips Co., Inc. are credited with many Geiger-Counter tube developments. One of the most promising industrial tools utilizing this tube is the Geiger-Counter X-ray Spectrometer. Dr. H. Friedman of the Naval Research Laboratories developed the basic design in cooperation with Philips. The principal departure from conventional X-ray diffraction equipment involves replacement of film with a highly-efficient self-quenching Geiger-Counter tube. Specially filled and designed for absorption of X-rays, this tube is so sensitive that a low intensity X-ray source is ample for all ordinary analysis work. In paint manufacturing, the spectrometer readily solves the problem of rutile and anatase mixture identification. Metallurgists now have a new way to handle phase identification, with two or more quantities present. Special tasks, difficult or impossible by other known methods, become much less complex in the manufacture of cellulose, cement, leather, lime, linseed oil, paper, plastics, precious stones, rayon, rubber, textiles, waxes, wood, cheese and dairy products.

NEARLY 3,500 veterans of World War II, including 2,000 former employes, already have been re-employed in Chicago district plants of Carnegie-Illinois Steel Corp. Many of these have been given postwar jobs despite physical handicaps. The corporation has learned through a comprehensive survey of the 44,000 employes who left their jobs to serve their country that, on the basis of the first 7,000 replies, 88 per cent or 6,160 plan to return to the company. Of the others, 9.6 per cent are undecided and the remainder do not intend to return. Of the latter, 103 plan to get schooling under the G.I. Bill of Rights.

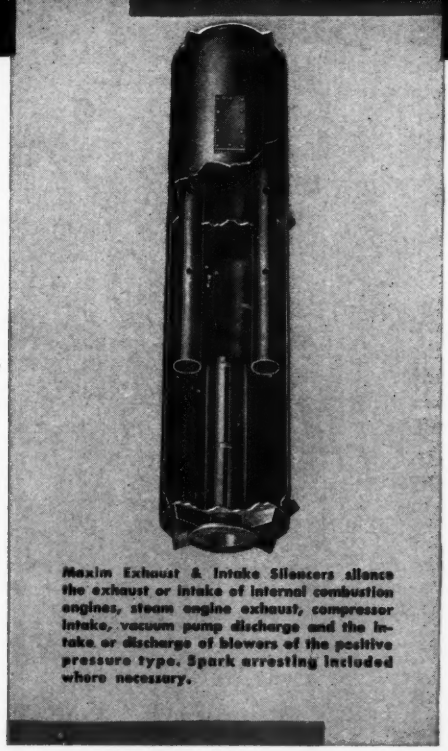
WHATEVER YOUR PERSONAL opinions about the present-day conflicts between industry and labor, you've got to admit tht right in the middle of them stands one of the most important figures in the entire industrial operation, who probably has more knowledge of both sides of a given personnel problem than anybody else—the industrial foreman. Hence you will do well, we think, to read regularly the Executive's Labor Letter, published every other Tuesday by the National Foremen's Institute. Its issue of December 12, the latest available at this writing, discusses the implications for both industry and labor of the various proposals now being made to solve labor difficulties and includes a special supplement on the need for an effective conciliation service, now that NWLB is dead, with some very specific recommendations as to how such a service could be established.

SCRATCHES so fine they are hardly discernible to the naked eye become deep gorges when the stylus of a Brush Surface Analyzer speeds over finished metals, glass, plastics, paper and painted surfaces. This analyzer can register defects only a millionth of an inch in depth. The analyzer operates on the piezo-electric principle. A diamond-tipped stylus moves across the surface to be tested and a piezo-electric crystal unit transforms the motions of the diamond point into electric impulses; these are amplified and then converted by a second crystal unit into mechanical motions, which drive an inked pen across a recorder chart.

LOOK FOR MANY developments in paper-making in the next decade. Paper makers have been experimenting for years with various methods intended to decrease the number of separate steps in the paper-making process, thus decreasing the cost—in other words, to get more directly from the wood in the log to the spread-out cellulose fibers in the sheet of paper. One of the methods developed for doing this is the groundwood pulp process, but this has had the disadvantage that discolorations of the original wood may go right through onto the paper. To bleach groundwood pulp, a new DuPont compound called Solozone, essentially a sodium peroxide chemical, has recently been used successfully for bleaching groundwood pulp. Fortune magazine is printing on paper made by this method; the paper is heavy, soft to the touch yet with a springiness and ink-absorbing quality very advantageous on high-speed presses.

KILL ENGINE EXHAUST NOISE

WITH MAXIM SILENCERS



Maxim Exhaust & Intake Silencers silence the exhaust or intake of internal combustion engines, steam engine exhaust, compressor intake, vacuum pump discharge and the intake or discharge of blowers of the positive pressure type. Spark arresting included where necessary.

Adequate silencing of engine exhaust noise is an operating necessity today. The engines shown above could, without proper silencing, make a public disturbance that would quickly be felt by those in charge of plant operation. With Maxim Silencers, however, exhaust noise can be reduced to a point where it is scarcely audible.

Maxim engineers will be glad to recommend the correct silencing equipment to best meet your particular problem. Send your specifications to the address given below.

Maxim also makes Heat Recovery Silencers which combine efficient silencing, spark arresting, and the recovery of waste exhaust heat to produce steam or hot water for heating or processing operations. These are described in Heat Recovery Bulletins WH 100, WH 101 and WH 103.

WRITE FOR BULLETINS describing exhaust & intake silencers D 125, D 127, D 101, D 37.

THE MAXIM SILENCER CO. 89 HOMESTEAD AVE., HARTFORD, CONN.

ARMY ★★ E ★★ NAVY

MAXIM

"There's an YARWAY

1 Floatless

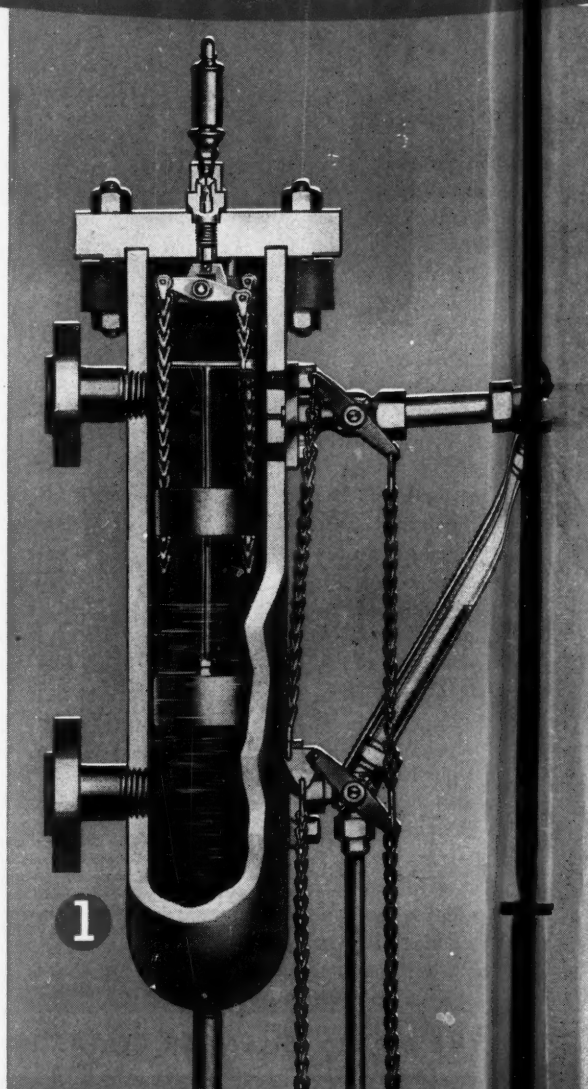
Yarway's Hi-Lo Alarm Water Column has an alarm mechanism that is simple . . . dependable . . . unique. Solid weights operate the whistle alarm. The principle employed is that heavy objects submerged or partly submerged in water are buoyed up by a force equal to the weight of the water they displace. Any dangerous change in water level causes the weights to open or close a needle valve through which steam is admitted to the alarm whistle. The alarm is always dependable . . . the weights can never become waterlogged. Yarway Column shown has Sesure Inclined Gage for pressures up to 400 psi. Flat Glass Gages furnished for pressures to 1500 psi. Ask for Bulletin WG-1810.

2 Remote

Yarway's Remote Water Level Indicator brings overhead boiler water level readings right down to eye level, on the instrument panel or other convenient place, on a brilliantly lighted red and green scale. Indication is *positive* and *instant* because the instrument is operated by the boiler water itself. Shows boiler water level beyond the range of overhead gage, and always indicates high or low—even when full or empty overhead gages look the same. Suitable for all pressures to 1500 psi. Ask for Bulletin WG-1820.

3 Seatless

Yarway's famous Seatless Blow-Off Valve eliminates one of the commonest sources of trouble and expense in boiler blowdown service. *There is no seat* to score, wear and clog with mud, dirt and scale. Balanced sliding nitralloy plunger and straight through flow make operation easy. Today this valve is "standard" in over 12,000 boiler plants. Suitable for all pressures up to 2500 psi. Ask for Bulletin B-424 (to 400 psi), Bulletin B-432 for higher pressures.

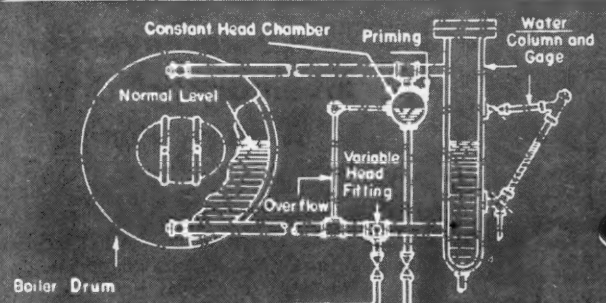


YARWAY

YARNALL-WARING COMPANY
114 Mermaid Ave., Philadelphia 18, Pa.

Engineering Reason"

BOILER TRIM



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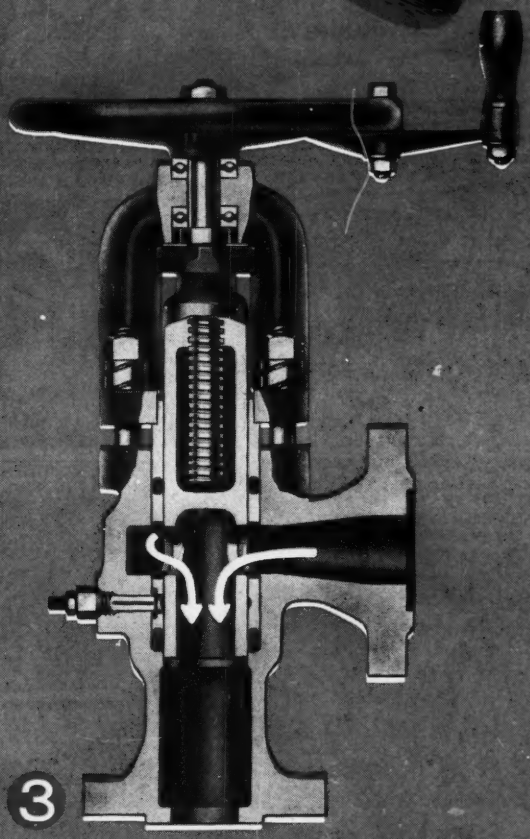


3

See Yarway Boiler Trim "in action" in the 30-minute color motion picture, "There is An Engineering Reason." Hear Lowell Thomas describe their principles and operation. Now available without charge for group showings. Write today.

STEAM PLANT EQUIPMENT

LOOKING for TROUBLE!

Designed to stand up in trouble spots, America's newest and widest line of V-Belts — Allis-Chalmers' Texrope — solves every one of these drive problems.

I FIND MY PLACE WHERE EXPLOSION IS A DANGER. I'M SUPER-7 STATIC RESISTING; MY BUILT-IN CONDUCTING ELEMENT CARRIES CHARGES TO THE MACHINE WHERE THEY'RE GROUNDED

Texrope V-belts are available nation-wide through Allis-Chalmers Dealers and Sales Offices. It pays to make Allis-Chalmers your V-belt drive headquarters.

ALLIS-CHALMERS

Texrope Super-7 V-Belts result from the cooperative research of two great companies—Allis-Chalmers and B. F. Goodrich—and are sold exclusively by A-C.

A 1962

BULLETIN!

SPEED RECONVERSION WITH HELP OF NEW FREE A-C KIT!

Guide to "How to Take Reconversion Inventory" of Drives, Motors, Pumps

Help in the big job of reconverting for peacetime production is now offered to plants everywhere by Allis-Chalmers Mfg. Co., its district offices and distributors. To all who request it, we're sending the new "Reconversion Inventory Kit", planned to speed the task of determining the condition of your existing equipment — V-belt drives, motors, and centrifugal pumps — which will be used in reconverted production.

SUGGESTS PROCEDURE, STATES STANDARDS

Used by foremen, maintenance men, and engineers, the Kit is a real time-saver . . . leads efficiently to probable trouble spots, helps clear them up. Gives bearing tolerances, resistance formulae, etc., in compact, easily-used form. Check List appraisal charts help determine present and future condition of units inventoried.

HOW TO GET YOUR KIT

For your free Reconversion Inventory Kit, call your nearest Allis-Chalmers distributor or district office, or write Dept. 139, ALLIS-CHALMERS MFG. CO Milwaukee 1, Wis.

ALLIS-CHALMERS MFG. CO.
Dept. 139, Milwaukee 1, Wis.

Please send Reconversion Inventory Kit free of charge to:

Company.....

Address.....

.....

Attn. of Mr.....

HEAR THE BOSTON SYMPHONY: *Every Saturday Evening, American Broadcasting Co.*

STEAM PLANTS

FROM BAILEY CONTROLS

1. Get More Steam Per Dollar

Save on fuel
Save on maintenance
Save on power for auxiliaries

2. Deliver Better Power Service

Reduce forced outages
Increase unit capacity
Maintain steam pressure on load swings
Insure adequate process steam
Prevent steam waste

3. Insure Safer Operation

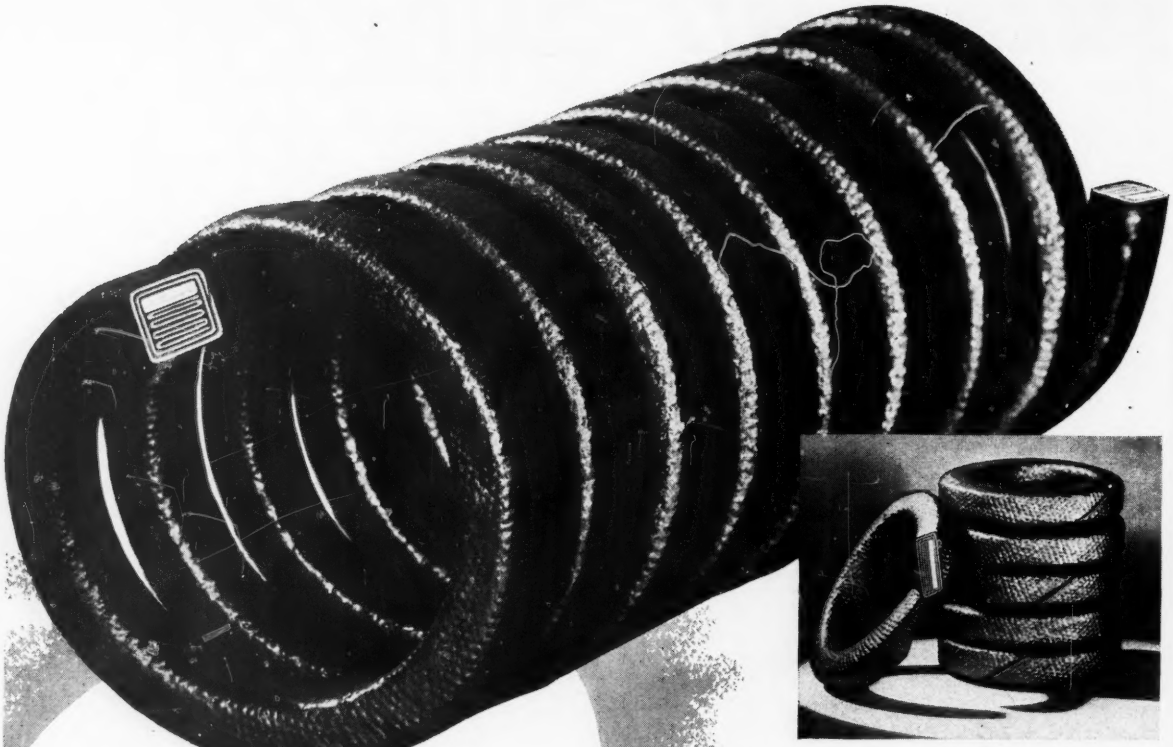
Reduce explosion hazard
Free operators to check any sign of trouble
Prevent excessive steam temperatures
Prevent water carryover and low water
Protect feed pumps at low rates

Application to Your Plant

If you would like to have this 3-way profit of money saving, improved power service, and greater safety for your plant, call on your local Bailey Engineer. He will analyze your layout and make recommendations. He is in a position to help you secure the 3-way profit which results from the intelligent use of correctly selected and properly coordinated steam plant controls.

BAILEY METER COMPANY
1040 IVANHOE ROAD • • • CLEVELAND 10, OHIO
Controls for Steam Plants

COMBUSTION • PRESSURE
FEED WATER • LIQUID LEVEL
TEMPERATURE • FEED PUMPS



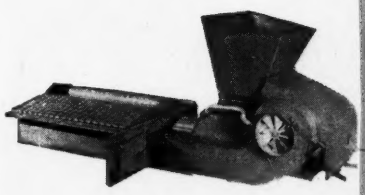
Large illustration shows GARLOCK 150 Spiral. Inset: GARLOCK 200—Rings, cut to size. Coil form—GARLOCK 125.

QUALITY *Controlled* for long Service

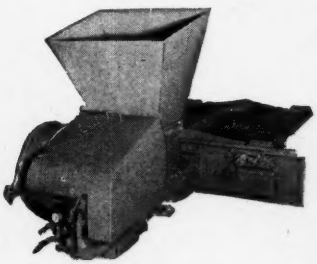
GARLOCK 150 High Pressure Steam Packing is tough, strong, dependable—because it is manufactured from start to finish in the Garlock factory in conformance with Garlock standards of quality. Each ingredient and each operation are *quality controlled* throughout. *Result:* a high pressure packing that gives long, economical service. For superior performance on piston rods of engines, pumps, compressors, expansion joints, etc., against steam pressures up to 300 lbs., specify GARLOCK 150.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
In Canada: The Garlock Packing Company of Canada Limited, Montreal, Que.

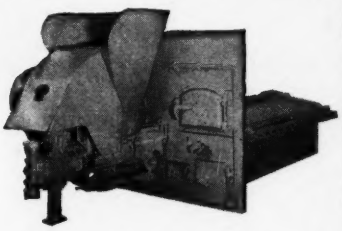
GARLOCK



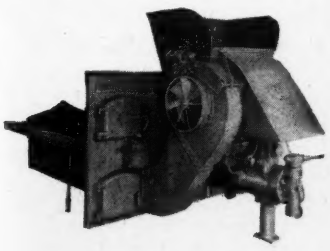
SERIES 40-A
. . . side set stationary or moving grates for Anthracite coal. Capacity 3,300 to 16,700 sq. ft. E.D.R. Steam. Electro-Hydraulic Drive.



SERIES 40-B
. . . center set stationary grates, ash dump for Bituminous coal. Capacity 4,500 to 25,000 sq. ft. E.D.R. steam. Electro-Hydraulic Drive.



SERIES 60-A
. . . with moving grates for Anthracite coal. Capacity 15,000 to 32,000 sq. ft. E.D.R. steam. Electro-Hydraulic or Steam Drive available.



SERIES 60-B
. . . stationary grates for Bituminous coal. Capacity 22,000 to 45,000 sq. ft. E.D.R. steam. Electro-Hydraulic or Steam Drive available.

Full Steam AHEAD!

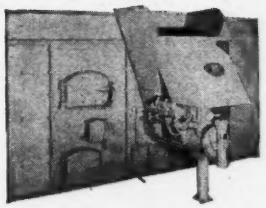
Whatever your power or heating requirements . . . continuous heavy daily schedules or extreme peak loads . . . there is an "F & E" Underfeed Stoker designed to operate your boilers for dependable trouble-free production of steam power.

Check these different "F & E" Stoker models with your heating or power requirements. Remember . . . only in "F & E" Stokers are found this combination of six engineered features that assure you *full* steam ahead to meet your required volume . . .

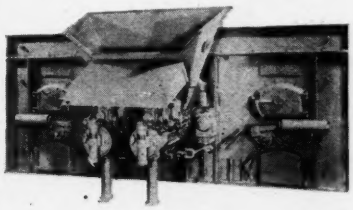
Unit-Type electro-hydraulic drive (steam drive available) . . . Interval timer governor coal feed control . . . Synchronized coal feed and air regulation . . . Moving retort bottom for proper coal distribution . . . Quickly adjustable fuel bed regulator . . . Specially designed high efficiency tuyeres

Your local "F & E" Representative will help you select the "F & E" Underfeed Stoker that will solve your steam production problems for all time . . . Make arrangements to see him today.

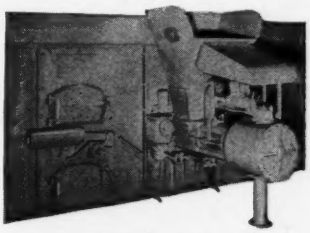
FLYNN & EMRICH CO.
Established 1842
HOLLIDAY & SARATOGA STS., BALTIMORE 2, MD.
Representatives in Principal Cities



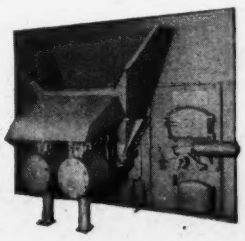
SERIES 70-E
. . . Electro-Hydraulic Drive. Single retort with stationary grates, 300 HP to 550 HP . . . with moving grates, 450 HP to 800 HP. Steam Ram Drive optional.



SERIES 70-E
. . . Electro-Hydraulic Drive. Double retort with stationary grates, 600 HP to 800 HP . . . with moving grates, 800 HP to 1000 HP. Steam Ram Drive optional.



SERIES 70-S
. . . Steam Ram Drive. Single retort with stationary grates, 300 HP to 550 HP . . . with moving grates, 450 HP to 800 HP. Electro-Hydraulic Drive optional.



SERIES 70-S
. . . Steam Ram Drive. Double retort with stationary grates, 600 HP to 800 HP . . . with moving grates, 800 HP to 1000 HP. Electro-Hydraulic Drive optional.

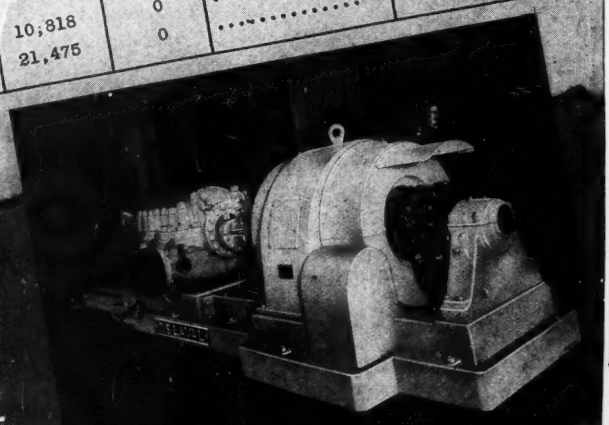
Look at the Record!

SERVICE RECORD—As of September 1, 1944

DE LAVAL PUMPS at _____

No.	Discharge Pressure psig	Suction Temp. °F.	Placed in Service	Total Service Hours	Outages Due to Pump	Cause of Outages	Approx. % Increase in Pump Power
14	1186	260°	12- 2-38	40,383	2	Replace ball locating bearing and shaft sleeves	Negligible
			10-11-40	28,839	1	Replace shaft sleeves	Negligible
15	1186	260°	8- 4-39	10,818	0	.....	Negligible
21	1186	350°	1- 2-42	21,475	0	.....	5%
16	1186	260°					

Capacity (all units).....1455 g.p.m.



of DE LAVAL HIGH-PRESSURE BOILER-FEED PUMP PERFORMANCE

Not one major trouble after as much as 40,000 hours of service!

The first of these units was installed in February, 1938; the most recent in February, 1942. All have demonstrated the satisfactory performance of De Laval boiler-feed pumps for high-pressure central station service.

Other important installations, operating at pressures up to 1600 psi and handling high temperature feed water, are operating with equal freedom from trouble, due in no small measure to the excellent performance of the De Laval automatic balancing device, the De Laval large clearance labyrinth wearing rings, and the sturdiness of De Laval solid end head construction.

3629

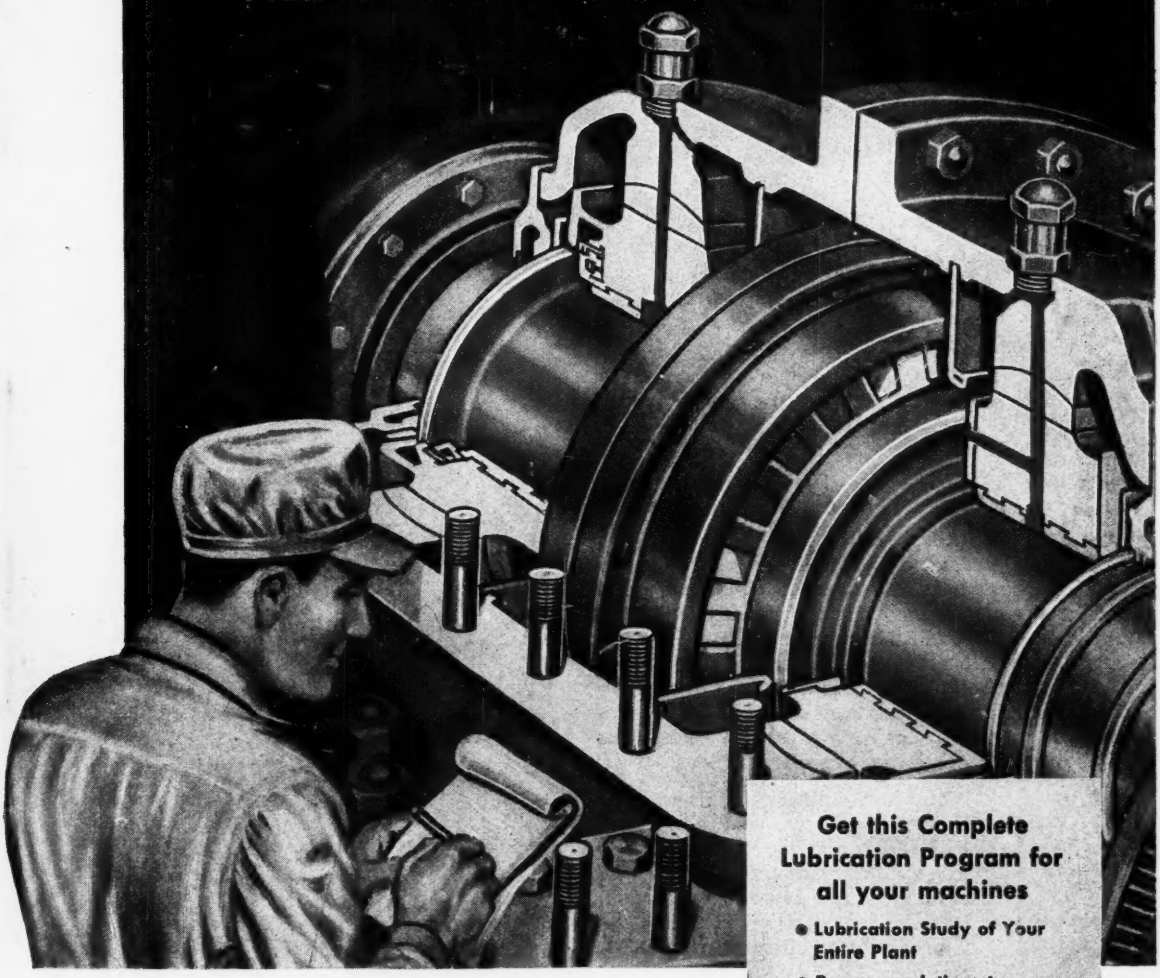
TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS and COMPRESSORS • IMO OIL PUMPS

DE LAVAL

STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

SALES OFFICES: ATLANTA • BOSTON • CHARLOTTE • CHICAGO • CLEVELAND • DENVER DETROIT • DULUTH • EDMONTON • GREAT FALLS • HAVANA • HELENA • HOUSTON KANSAS CITY • LOS ANGELES • MONTREAL NEW ORLEANS • NEW YORK • PHILADELPHIA PITTSBURGH • ROCHESTER • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE TORONTO • TULSA • VANCOUVER • WASHINGTON, D. C. • WINNIPEG

What's in this New Turbine Oil for you?



Extra Resistance to Oxidation and Rust!

In severe tests, Gargoyle D.T.E. Oil 797 has stood up longer than any other turbine oil. It is now in service in turbines ranging in size from 500 to 60,000 kw. Periodic inspections show freedom from oxidation deposits, and effective rust inhibition.

Superior Base Stock for Added Protection!

In Gargoyle D.T.E. Oil 797, these extra qualities are added to a base stock that is in itself an excellent turbine oil, possessing great resistance to oxidation and high lubricating value. The result, ideal oil for stepped-up temperatures and pressures.

Get this Complete Lubrication Program for all your machines

- Lubrication Study of Your Entire Plant
- Recommendations to Improve Lubrication
- Lubrication Schedules and Controls
- Skilled Engineering Counsel
- Progress Reports of Benefits Obtained

GARGOYLE Lubricants

Socony-Vacuum Oil Co., Inc.

and Affiliates: Magnolia Petroleum Co. · General Petroleum Corp. of Calif.

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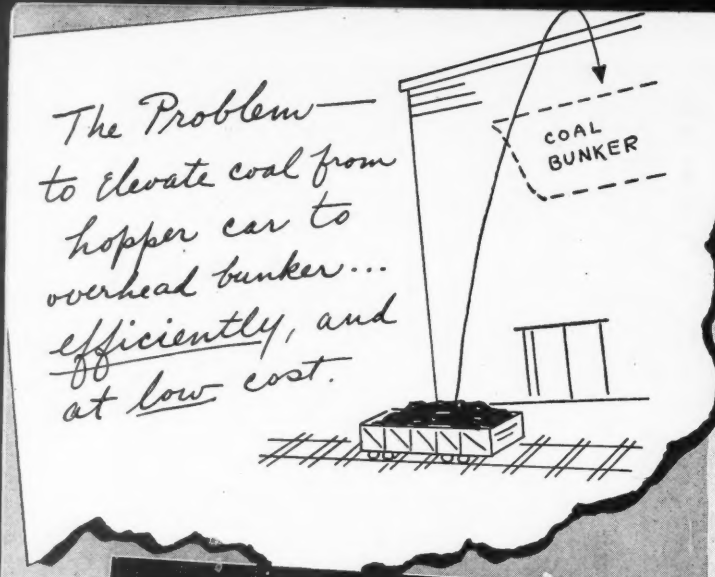
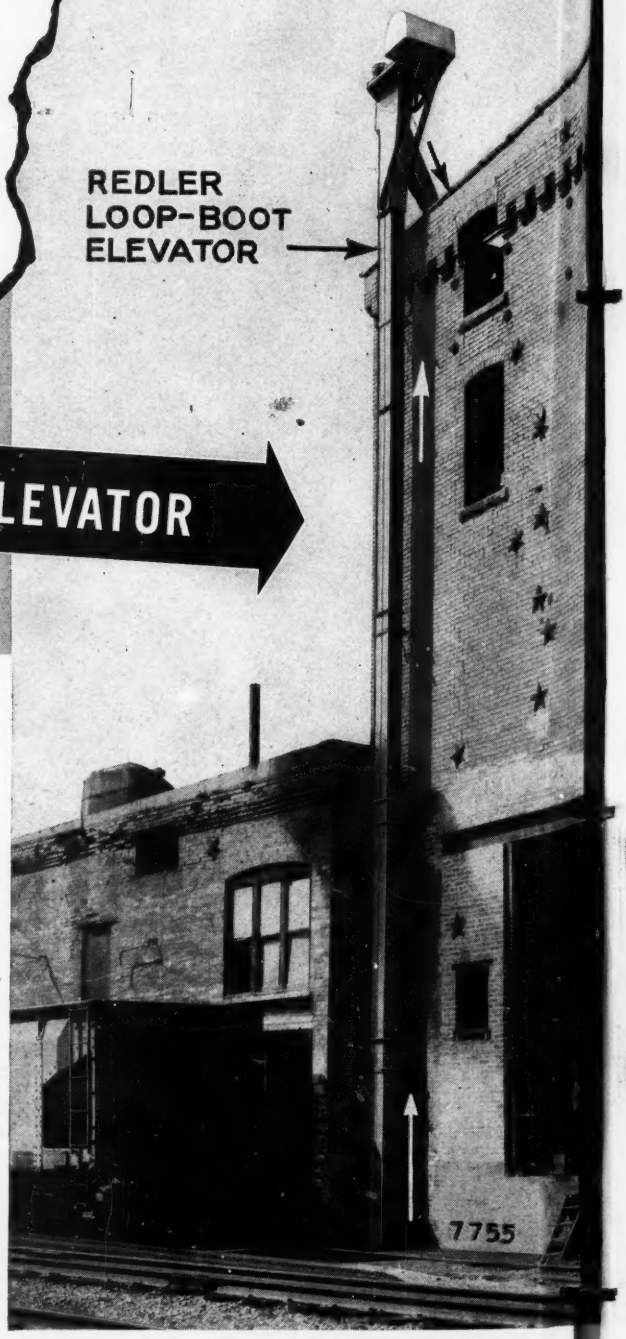
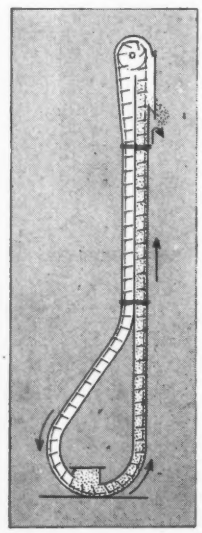


The Problem— to elevate coal from hopper car to overhead bunker... efficiently, and at low cost.

this S-A REDLER ELEVATOR was the *Obvious Answer*



A single self-feeding S-A REDLER Elevator provided this power plant with a rapid, economical and clean way to move coal from hopper cars to overhead bunker. Coal is discharged into a track hopper...into the choke feed opening of a loop-boot REDLER elevator . . . elevated up the outside wall of the boiler room and discharged through the roof into a large bunker...flows from the bunker by gravity to stoker hoppers. The enclosed casing of the REDLER provides thorough protection against weather and eliminates possibility of spillage or dust.



Note the simplicity of this installation: A *single*, compact, self-feeding REDLER does the entire handling job, with a minimum of supporting structures. and building alteration. For similar outstanding results on your handling problems consult S-A engineers.

REDLER "En Masse" Handling Units FIRST—AND FINEST

Remember that the REDLER is the original continuous-flow mass-movement conveyor. Often imitated, it has never been equalled. S-A engineers, first to develop this highly efficient handling method, have kept the REDLER in the forefront of "en masse" conveying units. In the past, thousands of REDLERS have been placed in service and are doing outstanding jobs.

Note how little space the REDLER occupies...how few supporting members are needed! Yet this compact unit handles large tonnages through a relatively small cross section. This REDLER has been in continuous faithful operation for over ten years.

STEPHEN S-A DAMSON MFG. CO.

515 RIDGEWAY AVENUE, AURORA, ILLINOIS — LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

Designers and Manufacturers of All Types of

BULK MATERIAL HANDLING EQUIPMENT

HOW MANY VALVES

COULD YOU TURN IN A MINUTE?

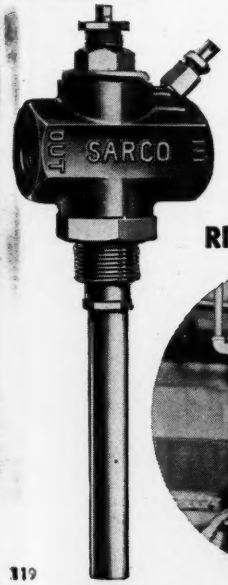
It depends on how fast you can run—for the points at which simple temperature control is needed are distributed all over your plant.

Also, requirements for cooling water on engine, compressor jackets and condenser, for heat in process work and even the hot water service for washing and showers, vary by the minute. An army of men couldn't run fast enough to keep temperatures in line.

And the cost of turning valves by hand is tremendous—in wasted heat and water—in rejects or delayed production. The cost of controlling temperatures with Sarco is low and soon forgotten. There is a simple, reliable, inexpensive Sarco control for every heating and cooling operation in your plant. Ask the nearest Sarco representative or send for the Sarco Hook-Up Book.

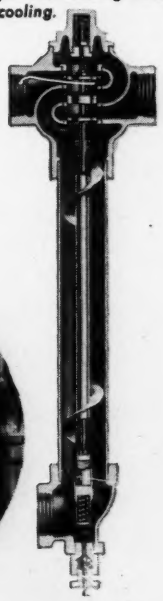
SARCO TR-40

A simple cooling control for compressors, condensers and stills — saves up to 50% of the cooling water.

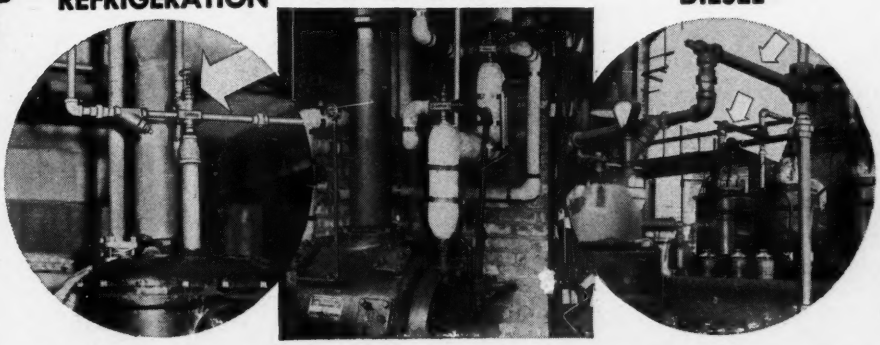


SARCO BLENDER

For Diesels, Showers, process heating and cooling.



REFRIGERATION **AIR COMPRESSOR** **DIESEL**



119

FOUR STARS ON OUR E PENNANT TESTIFY TO SARCO PERFORMANCE IN THE WAR EFFORT

ARMY E NAVY

SARCO SAVES STEAM

Represented in Principal Cities

SARCO COMPANY, INC., 475 FIFTH AVE., NEW YORK 17, N.Y. • Sarco Canada, Ltd., 85 Richmond St., W., Toronto 1, Ont.

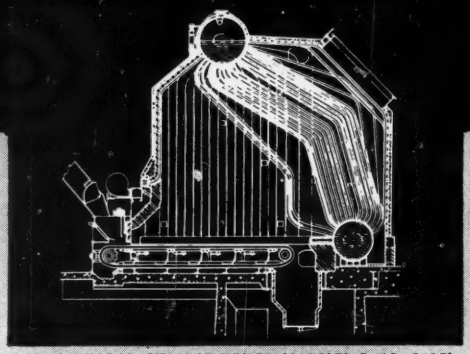
Use B&W BOILERS *for* LOW COST STEAM

ANY CAPACITY • ANY PRESSURE

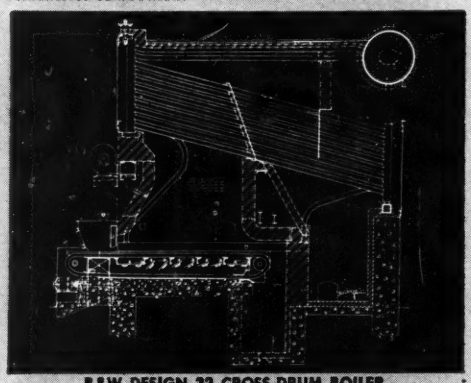
ANY TEMPERATURE

ANY SPACE • ANY FUEL

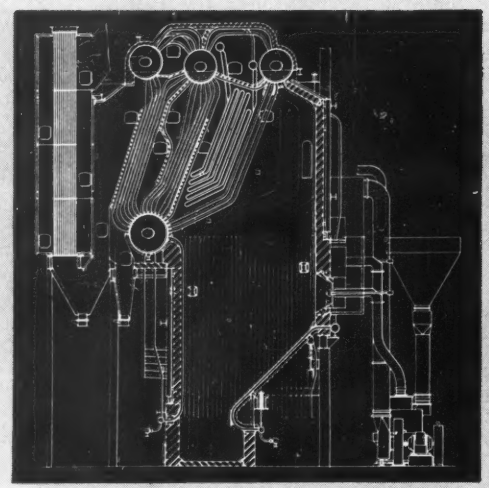
Highest standards of performance with respect to continuity of service, dependability, over-all operating efficiency, and greatest return on investment, are assured when any job of supplying steam requirements is entrusted to B&W Boilers. From the wide variety of time-tested, performance-proved B&W boiler designs, you can always be sure of getting units having the features necessary to provide economical steam generation under any combination of capacity, pressure, temperature, fuel and space requirements encountered in modern boiler installations. When you call on B&W for boilers, you call on a background of over 60 years' unsurpassed experience in designing, building steam generating equipment having a long record of highly satisfactory service wherever steam is used.



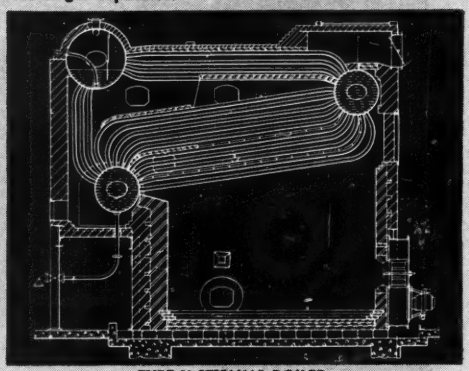
B&W INTEGRAL-FURNACE BOILER (CLASSES 9, 12, & 15)
This Integral-Furnace Boiler is available for firing with stokers or with oil, and in sizes ranging from 1353 to 6506 sq. ft. of heating surface. Having a water-cooled furnace of special design, this boiler provides the dependability of central-station boilers, with efficient and smokeless combustion.



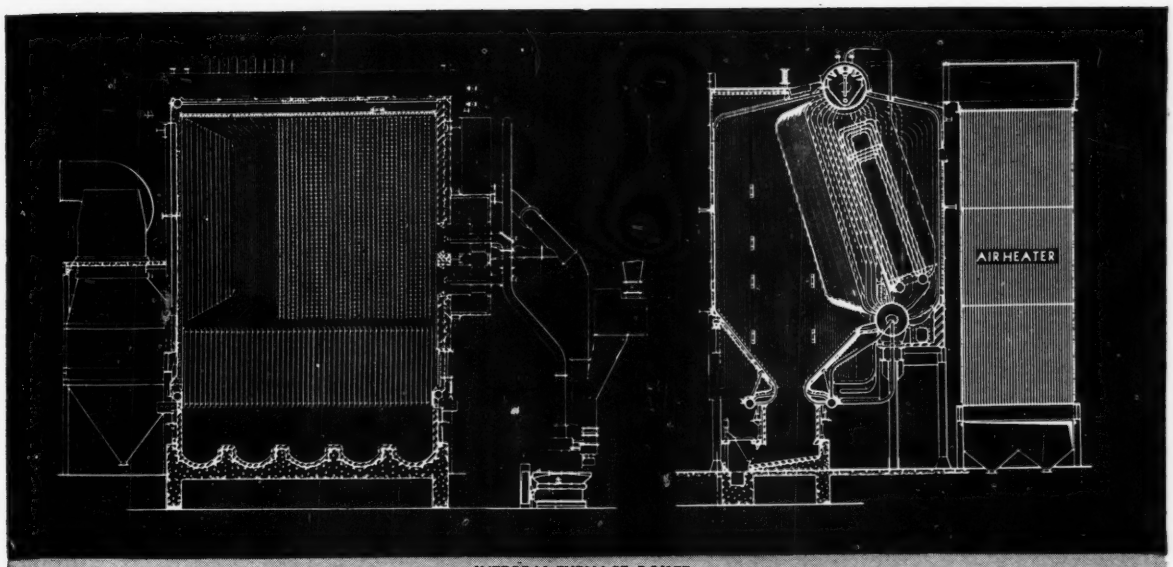
B&W DESIGN 32 CROSS-DRUM BOILER
This unit is widely used in small and medium-size power plants where refractory furnaces are suitable. It provides the advantages of the straight-tube, sectional-header construction used in B&W Cross-Drum Boilers designed for larger capacities.



STIRLING BOILER
The Stirling Boiler fully meets the requirements of modern operating conditions. It readily responds to sudden and heavy demands for steam, and delivers dry steam at relatively high ratings when operated with water having a high concentration of solids. May be fired with any fuel.

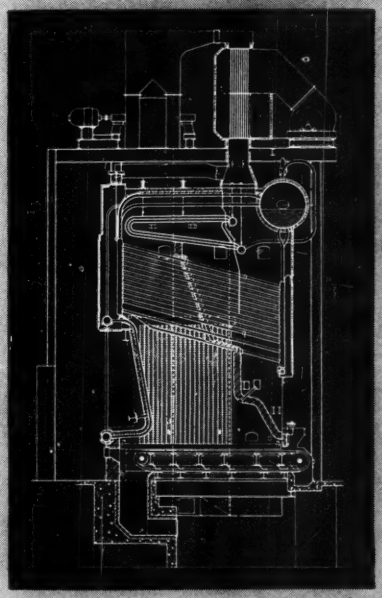


TYPE H STIRLING BOILER
A low-head moderate-pressure unit that is widely used in small industrial plants, institutions, hotels, office buildings and to meet other similar requirements. Available in capacities ranging from 1500 to 30,000 lb. steam per hr. and for firing with any fuel. The furnace, usually of refractory, provides the necessary degree of dependability.



INTEGRAL-FURNACE BOILER

The Integral-Furnace Boiler is a completely co-ordinated unit built in wide range of steam capacities and for pressures and temperatures required by the most up-to-date and efficient prime movers. It is designed to burn pulverized solid fuels, oil, or gas, singly or in combination, thus utilizing at high combustion efficiency the least expensive fuel obtainable in any locality.

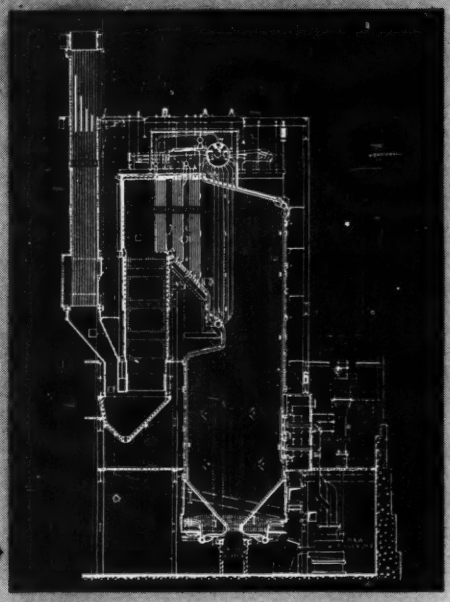


B&W CROSS-DRUM BOILER

This straight-tube sectional-header boiler is noted for its dependability, long life, and ability to deliver dry steam at high ratings. Can be readily inspected and cleaned.

CENTRAL-STATION BOILERS

High-duty boilers for central-station service are available in several basic designs to meet the requirements of individual stations. The Radiant boiler unit illustrated is typical of some of the units now operating at high rates in utility plants.



Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

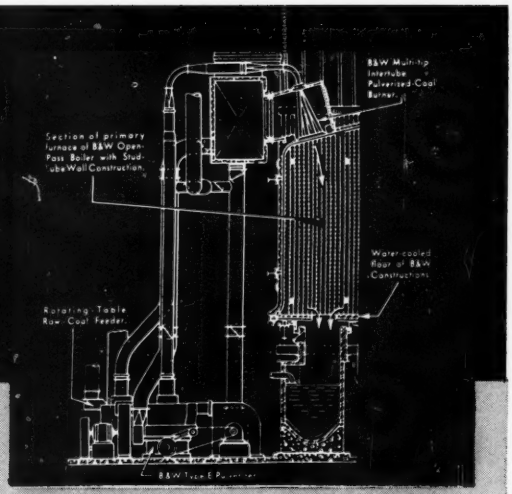
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.

85 LIBERTY STREET, NEW YORK 6, N.Y.

G-315T

CUT STEAM COSTS with B&W COMPONENT EQUIPMENT

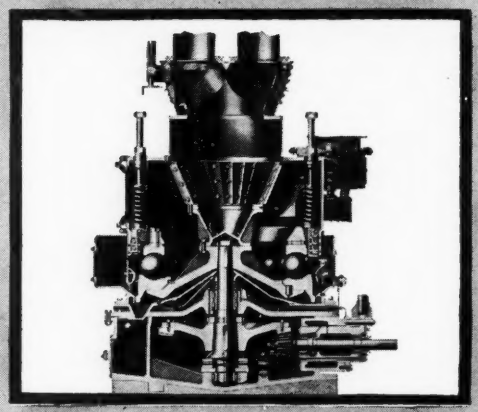

B&W Multi-tip Interlube Pulverized-Coal Burner
Section of primary furnace of B&W Open-Pass Boiler with Stud-Tube Wall Construction
Water-cooled Floor of B&W Construction
Rotating Table Raw-Coal Feeder

B&W DIRECT-FIRING PULVERIZED-COAL SYSTEM. B&W direct-firing pulverized-coal system has advantages in ease of operation, reliability and upkeep that make it economical for small as well as large boilers. It is readily applied to oil-fired boilers for conversion to coal firing.

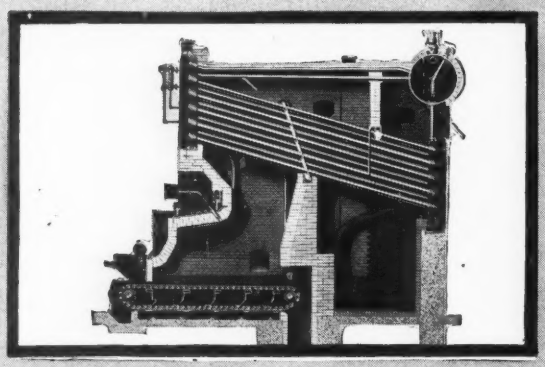
The various component equipment shown on these pages accounts to a large degree for the high standards of dependability, availability, efficiency and flexibility which have characterized the performance of B&W Boilers for over 60 years wherever steam is used.

Because B&W builds boiler units with all essential components—from fuel-preparation and burning equipment to breechings and stacks—the company has full control over both design and application of complete equipment. All component features are thus coordinated to assure maximum dependability and economy of operation under the service conditions of each specific installation.

Many of the B&W component features shown can be applied to modernizing existing boiler plants to step up efficiency and reduce steam costs. These are good reasons why it pays to see B&W first on any steam generating requirement.

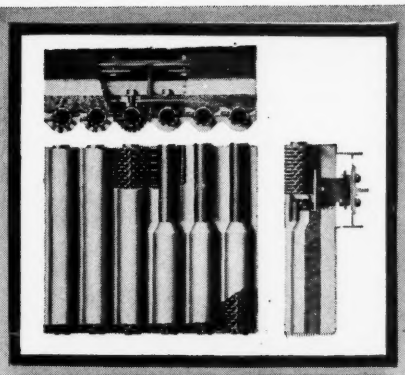


B&W PULVERIZERS. The simplicity and sturdiness of B&W ball-bearing type pulverizers assure high availability with low maintenance in direct-firing pulverized-coal systems. They provide consistently high fineness and respond quickly to changes in load with automatic control of raw-coal feed.

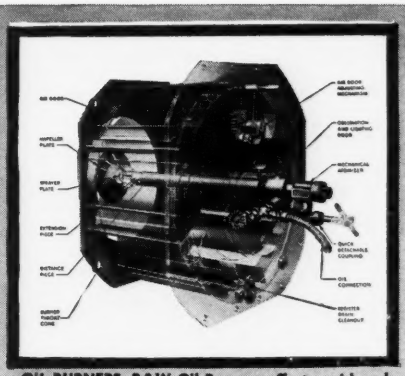


CHAIN-GRATE STOKERS. Babcock & Wilcox Chain-Grate Stokers are widely used with free-burning bituminous coal, anthracite, lignite, and coke breeze. They can be furnished for natural, induced, or forced draft, depending upon operating conditions.

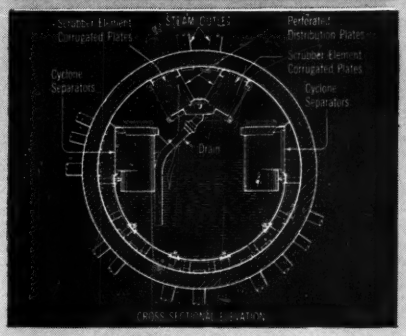
REFRACTORIES. Low heat conductivity, long service life, high hot-load strength, high resistance to spalling, structural stability and light weight are features of B&W specialty refractories that assure low maintenance, fuel economy and efficient furnace operation.



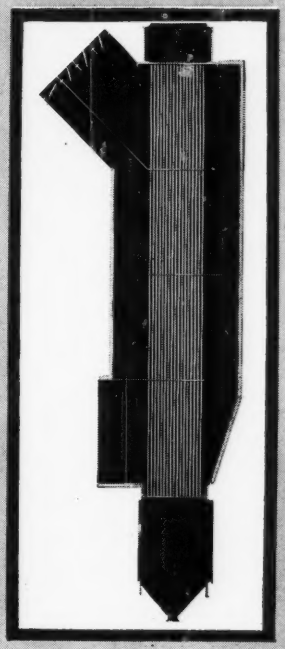
WATER-COOLED FURNACE CONSTRUCTIONS. B&W Water-Cooled Furnace Constructions are extensively applied for partial or complete water cooling of furnaces of all sizes, shapes, and forms, and with all fuels and combustion methods. Studded-tube type of construction is shown.



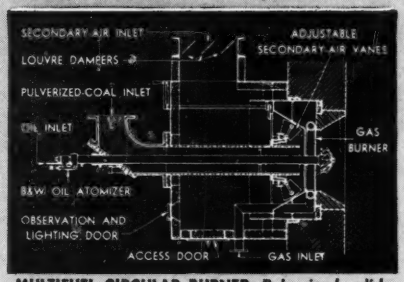
OIL BURNERS. B&W Oil Burners effect rapid and complete combustion at all rates of fuel feed, using mechanical, steam, or steam-mechanical atomizers, depending on the oil and operating conditions. Available in a range of heat liberating capacities that meet all requirements.



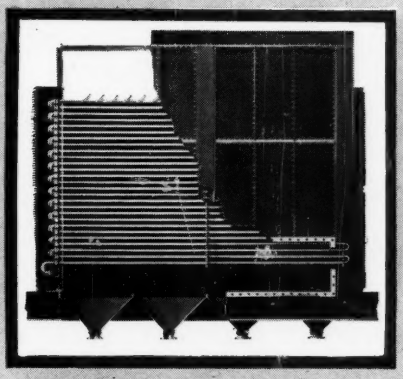
CYCLONE STEAM SEPARATOR. Elimination of solids and moisture from steam in boiler drums, and promotion of boiler water circulation by mechanical means are accomplished with a high degree of effectiveness by the Cyclone Steam Separator.



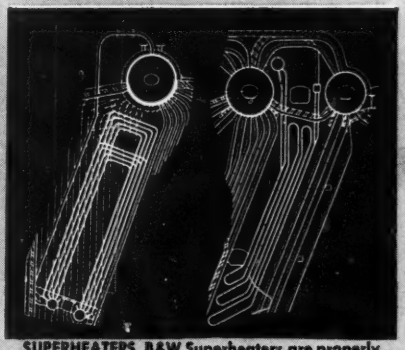
AIR HEATERS. B&W Tubular Air Heaters are inherently tight and efficient, and are easy to keep clean. Available in multi-pass gas flow type, as shown, or longitudinal gas-flow type, and in sizes to meet the requirements of any boiler installation.



MULTIFUEL CIRCULAR BURNER. Pulverized solid fuels, oil, and gas are burned singly or in any combination with this burner. It provides a single means of efficiently burning a wide range of fuels, permitting advantage to be taken of variations in the availability and market prices of these fuels.



ECONOMIZERS. B&W Economizers effect appreciable savings in fuel and can be built to meet the size and pressure requirements of any installation. The Return-Bend Economizer shown can be easily cleaned, and pressure parts may be inspected externally while in service.



SUPERHEATERS. B&W Superheaters are properly designed and fabricated, with respect to steam and gas flow, to function efficiently with boilers designed and built by B&W. Available in both draining and non-draining types

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

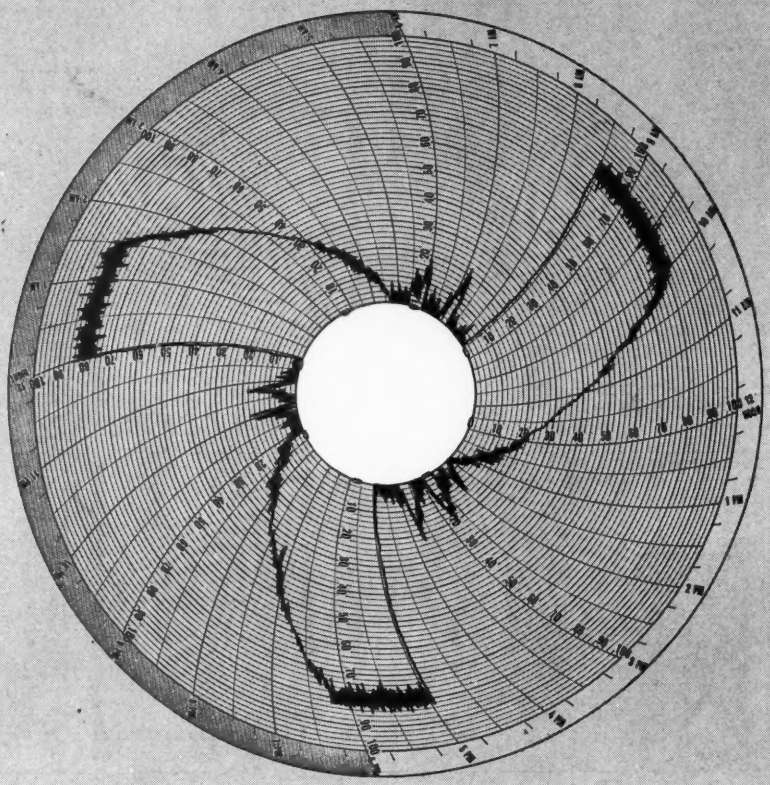
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.

85 LIBERTY STREET, NEW YORK 6, N.Y.

G-315F

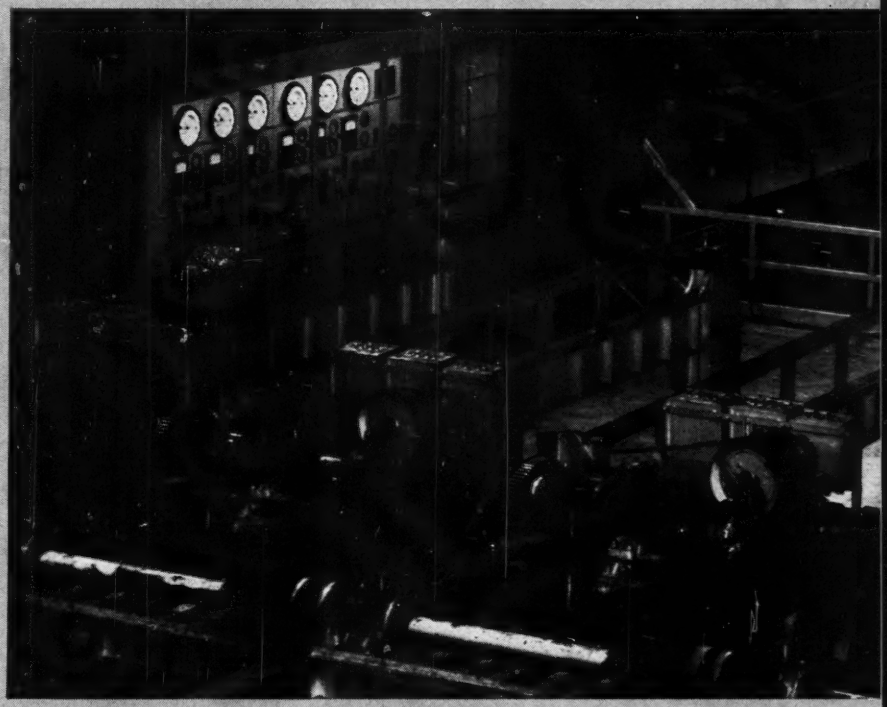
The flow-meter "No fuel"



HAGAN CORPORATION, HAGAN BUILDING, PITTSBURGH 30, PA.

said

but the Hagan Control knew better



IT HAPPENS RIGHT ALONG in a Pennsylvania steel plant, where Hagan Automatic Combustion Control is used on soaking pits.

Large amounts of fuel are needed to bring the cold ingots up to temperature. After they have been heated, a very small percentage of the maximum amount holds the pit temperature at the correct level. When fuel demand drops down around 8%, the flow meter registers zero—but hour in and hour out Hagan Control continues to supply the right amount of fuel to maintain the right temperature.

Only one thing makes this possible—the Hagan principle that *controlling and recording are separate functions.*

The operation of the Hagan Automatic Combustion Control System is dependent on the functioning of a number of coordinated regulating machines, each designed for its specific job as a *regulator.* Its efficiency has not been impaired by attempting to make it serve the dual purpose of controlling and recording.

Every secondary recording instrument on the panel can be inaccurate or out of service without the slightest effect on the functioning of Hagan Control.

Write for full information.

HAGAN
HALL
BUROMIN
CALGON

HAGAN *Automatic* COMBUSTION CONTROL

The pioneer . . . and still the leader

ASBESTOS IN ACTION
WITHSTOOD BOTH
HURRICANE
and
FIRE!

ASBESTOS IN ACTION
HIGH, WIDE and HANDSOME!
. . . and SAFE because it's sheathed with "Century" APAC
THE striking architecture of this Navy Blimp hangar is its own tribute! The doors are like skyscrapers 120 feet high 220 feet wide weighing 300 tons. And they must open the entire width of the hangar in TWO MINUTES.
These giant portals must be the masters of wind and weather—for failure to open and close quickly might spell the doom of a wind-tossed Blimp. So they are completely sheathed with "Century" Apac—K&M's low cost asbestos-cement sheet material. It is rot-proof, rust-proof and fire-resistant.
In thousands of industrial plants, K&M "Century" Apac is used for roofing and siding, office panelling, sheathing in machine shops and stock rooms, linings for elevator casings and shower stalls. It is ideal for new construction, repairs or plant additions.
Enormous quantities of "Century" Apac have gone into wartime jobs. YET NOW THERE'S PLENTY AVAILABLE FOR YOUR INDUSTRIAL CONSTRUCTION WORK . . without delay, without restrictions.
Check these "Century" APAC advantages for roofing and renovation work
1. Made of Asbestos Fibre and Portland Cement
2. Fireproof, rust proof, rotproof
3. Can be painted any color
4. Comes in standard sizes—4' x 8', 4' x 9' and 4' x 10' (Other sizes to order)
5. Easy and quick to apply
6. Cuts and punches readily
7. Easy to handle, weighs approximately 1½ lbs. per sq. ft.
8. Practically no maintenance
9. Fireproof
10. Prompt delivery
Nature made Asbestos
KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

This advertisement originally appeared in April 1945

BETTER THAN we had anticipated . . . the outstanding performance of K&M "Century" APAC used as sheathing on the hangar doors of the Richmond, Fla., Naval Air Station. While the hangars themselves were completely destroyed by the fire and hurricane of September 16th, the *doors remain intact.* On-the-scene estimates indicate that *only* 5% of the APAC sheets were damaged . . . necessitating repairs of a very minor nature, considering the magnitude of the disaster. LET THIS OUTSTANDING BUILDING MATERIAL GO TO WORK FOR YOU.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos

SIMPLEX

INCREASE FLOW CAPACITY 40% TO 60%

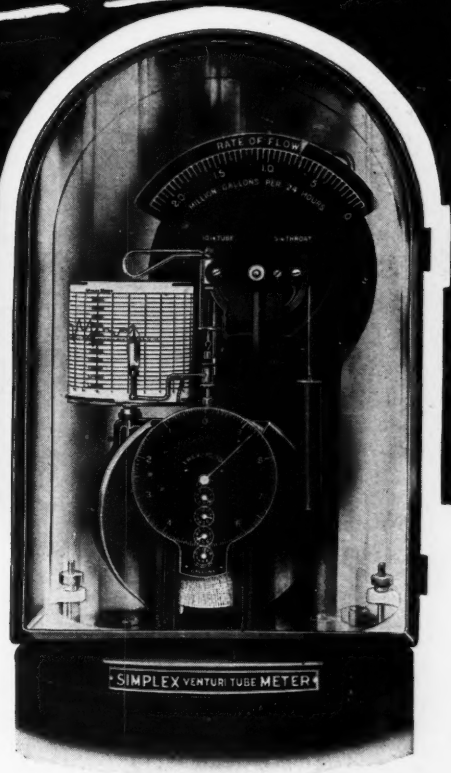
MOL or MOLA METERS

with flow ranges

FROM **20 to 1**

TO **28½ to 1**

OR TO **40 to 1**



Two typical examples of the ease and economy of increasing the maximum capacity of flow lines with the use of Simplex MOL and MOLA wide-range meters are given below:

1. **A change in operating heads enabled a large municipal water department to increase the total capacity of one of their pumps from a maximum of 60 million gallons per day to 72 million gallons per day by replacing the existing Simplex MO Meter with a Simplex MOL Meter. No change in the Venturi Tube, Pump Impeller, or motor was required, and operating costs showed a marked decrease.**

2. **By substituting an MOLA Meter for an MO Meter, increased requirements were met without any change in the Venturi tube, permitting an increase of from 13 million gallons per day to 21 million gallons per day.**

Simplex MOL and MOLA meters are designed to function over extremely wide flow ranges—and the accuracy of measurement and totalization is maintained at both maximum and minimum ends of the range.

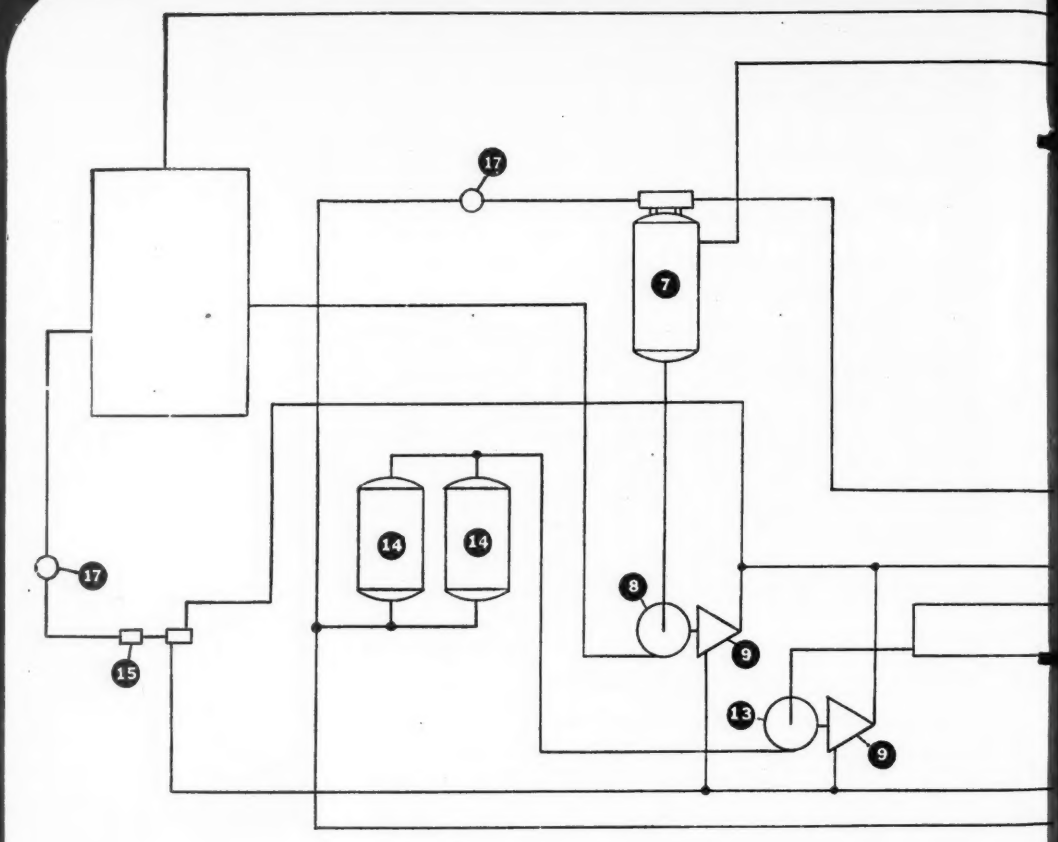
Look into the advantages and economies of making use of Simplex instruments for performing the extraordinary as well as the conventional metering operation.

Write today; our recommendations are made without obligation.

SIMPLEX VALVE & METER COMPANY

4733 UPLAND STREET, PHILADELPHIA 42, PA.

IT'S WORTHINGTON...



1 Extraction Turbine.
2 Generator & Exciter.
3 Switchgear.
4 Condenser.
5 Condensate Pump.
6 Steam Jet Air Ejector.
7 Deaerator.
8 Boiler Feed Pump.
9 Mechanical Drive Turbines.

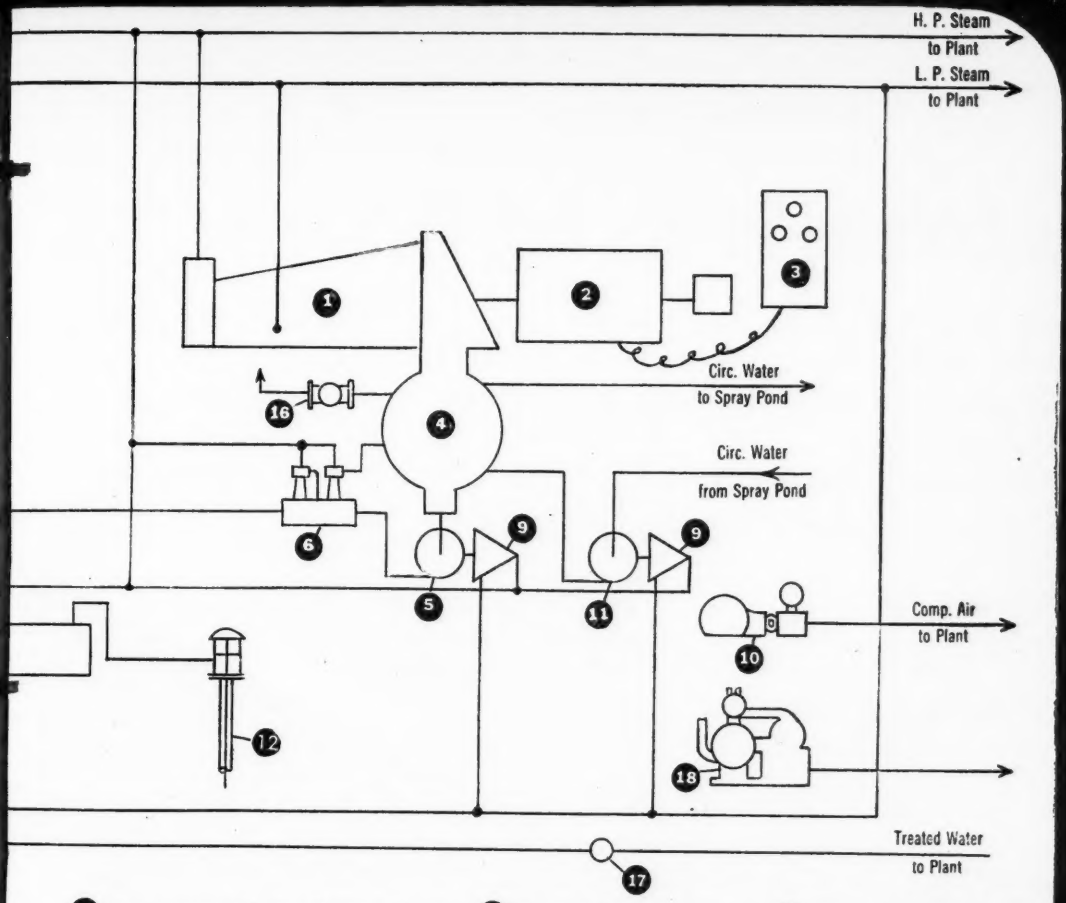
18 *Major Items of Equipment for Steam Power Plants Are Products of Worthington*

When planning equipment for steam power plants, the name Worthington becomes a logical consideration, because the Worthington line is the most complete . . . backed by engineering staffs that have been responsible for many of the important advancements in the handling of steam and water in power plants.

The flow sheet, representing a typical steam power plant of approximately 7500 kw. capacity, suggests the various items of equipment available under the Worthington trade-mark.

If you have known of Worthington through experience with any one of their products, you will be interested to learn about other types manufactured by the same company. Worthington engineers specializing in equipment for steam power stations are available in all parts of the world. Send the coupon today for information that may serve as the first step in experiencing why *there's more worth in Worthington.*

in Steam Power Plants



10 Compressor with Synchronous Motor.
11 Circulating Water Pump.
12 Deep Well Pump
13 General Service Pump.
14 Ion Exchange Softeners.
15 Fuel Oil Pumps.
16 Atmospheric Relief Valve.
17 Meters.
18 Air Conditioning and Refrigeration Equipment.

WORTHINGTON

FIRST IN STEAM POWER

J5-4

WORTHINGTON PUMP & MACHINERY CORPORATION
Harrison, N. J.

Please send me, without obligation, literature on items checked below.

(1) (2) (3) (4) (5) (6) (7) (8) (9)
(10) (11) (12) (13) (14) (15) (16) (17) (18)

NAME .....

COMPANY .....

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☐ *Check here to have a Worthington representative call.*

THE ALCO FUEL

for high efficiency and economy

An Extended-Surface Heat Exchanger

Reconversion to peace is under way, and this new ALCO standardized product is a head start to conversion for industrial oil-burner installations.

The heavier-grade and less-expensive oils require preheating for proper atomization and efficient combustion.

Now offered for IMMEDIATE SHIPMENT FROM STOCK, this Alco Fuel Oil Heater offers these important features:

1. HIGH HEAT TRANSFER DUE TO:

Superior baffle design and arrangement.

2. SIMPLICITY OF DESIGN:

A single U tube expanded into removable cover plate.

4. STANDARD SIZES AND LENGTHS:

Six sizes of standard units provided. High-efficiency heat exchangers of any capacity can be built up from these standard ALCO "X-Fin" units.

3. EASY TO CLEAN:

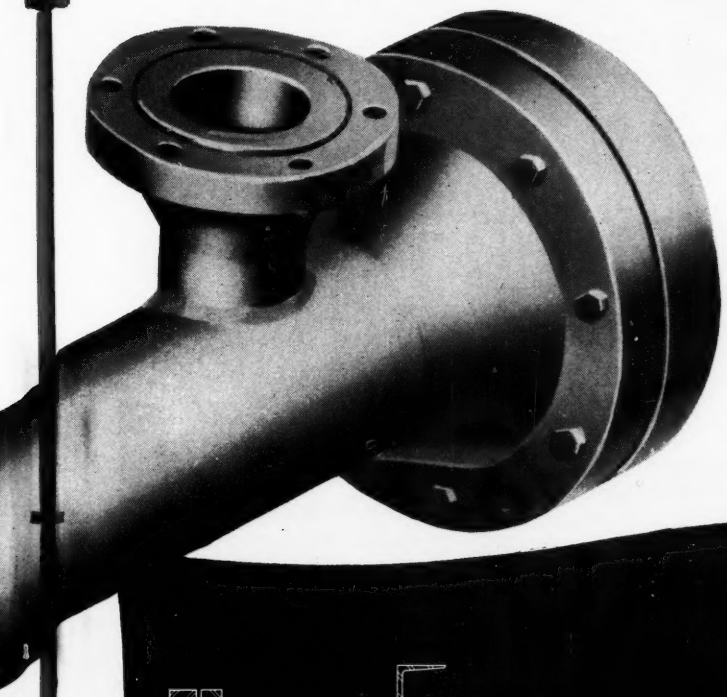
Baffle assembly easily separable from heat-transfer element.

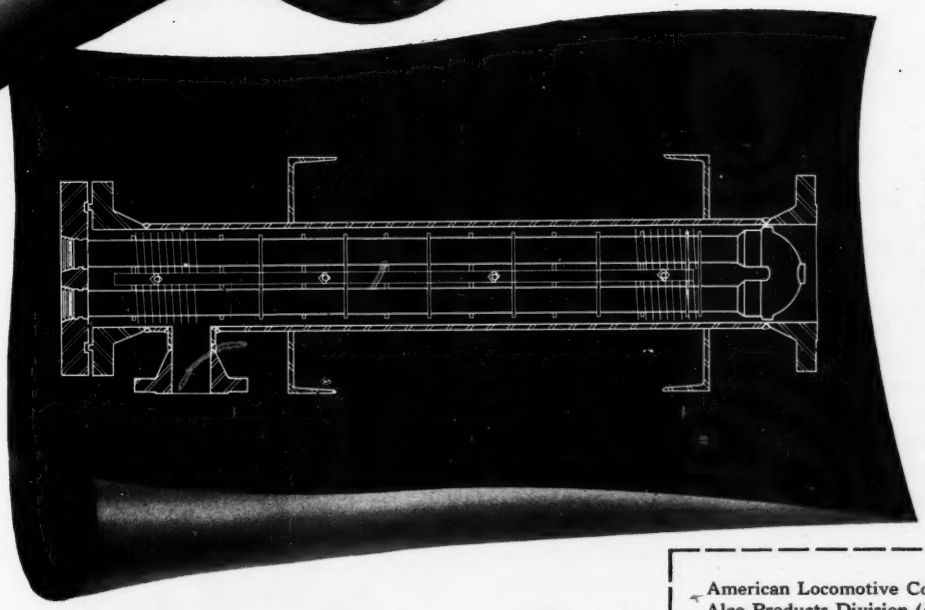
HUNDREDS USED DURING THE WAR, in a wide range of applications besides fuel-oil heating. Here are a few of many suitable applications:

1. Pre-heaters for oil refineries, natural-gasoline plants, chemical plants. **2.** Residuum exchangers. **3.** Solvent plants. **4.** Gas and air heaters. **5.** Heaters for caustics, acids, alcohols and other chemicals. **6.** Kerosene and gasoline heaters; propane vaporizers and superheaters. **7.** Lube-oil coolers. **8.** Quench-oil coolers. **9.** Duo-Sol coolers. **10.** Coolers for alkylation plants. **11.** Gasoline and kerosene coolers. **12.** Coolers for absorption processes. **13.** Gas and air coolers. **14.** Compressed-air aftercoolers.

OIL HEATER

in space...weight...cost...and maintenance





OTHER ALCO PRODUCTS:

Oil-Tank Suction Heaters · Feed-Water Heaters

Evaporators · Reboilers

Air-Cooled Heat Exchangers · Lube-Oil Coolers

Jacket Water Coolers · Vapor Heat Exchangers

Vapor Condensers · Waste-Heat Boilers

Prefabricated Piping · Electric-Welded Steel Pipe

Pressure Vessels · Pipe-Line Filters

Weldments

Write for New Bulletin

A copy of the new ALCO Bulletin, No. 1036, describing and illustrating this new line of ALCO products will be sent you promptly, on request. Write for it today.

American Locomotive

ALCO PRODUCTS DIVISION

30 Church Street, New York 8, N. Y. • Dunkirk, N. Y.

American Locomotive Company
Alco Products Division (8)
30 Church Street, New York 8, N. Y.

Please send me your new bulletin #1036, about the Alco Fuel Oil Heater.

Name.....

Title.....

Company.....

Street.....

City and State.....

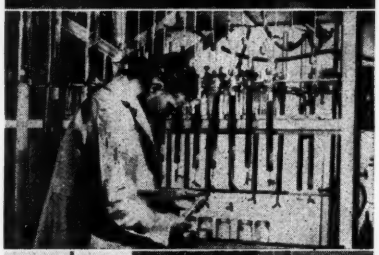
Something new is being added...

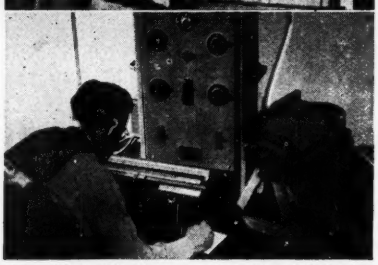
to make the *Nalco* System of water treatment an even *greater* service to industry

Not content with the world's finest and most modern water treatment laboratories . . . Nalco is now enlarging its research and laboratory facilities to make the Nalco organization even further advanced in the science of water treatment.

New technological and manufacturing processes springing up in this postwar era are bringing with them new problems in water treatment . . . *Nalco will be ready to help you solve these problems!*

Keeping well *ahead* of your water treatment problems has always been an aim of the Nalco organization. Our trained engineers and chemists and our entire research and laboratory facilities are at your disposal. Just ask for a Nalco survey . . . we will do the rest.





NATIONAL ALUMINATE CORPORATION

6224 West 66th Place • Chicago 38, Illin

Canadian inquiries should be address to Aluminate Chemical Ltd., 555 Eastern Ave., Toronto, Ont.

Nalco

—The System of Scientific Water Treatment for all Industry

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below; detach and mail.

BOILER PLANT

1 **Spreader Stokers**—Bulletin No. 78 describes the Fry-Feeder multiple spreader type stoker under the theme "burns coal like oil." The principle of the multiple spreader stoker is included with detailed illustrations and installation data. American Coal Burner Co.

2 **Electric-Welded Steel Boilers**—Bulletin S-67 describes the 3-pass gas travel, large combustion chamber, low water line and other features of the Brownell electric-welded heating boilers. Ratings up to 220 hp.—hand, stoker, oil or gas fired. The Brownell Co.

3 **Refractories and Heat Insulations** - New catalog describes R & L plastic insulation, insulating block, inside duct lining, refractory cement, plastic fire brick and similar materials. Contains installation photos, specifications, helpful engineering tables. Refractory & Insulation Corp.

4 **Fuel Oil Heater**—High test transfer, simplicity of design, easy cleaning and [illegible] features of the Alco fuel oil heater described in new Bulletin 1036. Unit may also be used as pre-heater for chemical plants, gas and air heaters, compressed air after coolers, etc. American Locomotive Co.

5 **Coal Hopper Vibrators**—Catalog folder No. 1-44 furnished information on electric vibrators for bins, hoppers and chutes assuring free flowing coal. Syntron Co.

6 **Boiler Installations**—New pictorial bulletin shows typical installations of Union Boilers in paper mill, oil refinery, steel foundry, hospital, municipal light plant and other industries. Specifications and boiler design are given for each job. Union Iron Works.

7 **Underfeed Stokers** — The unit type electro-hydraulic drive and other features which help assure even fuel distribution and perfect combustion in Flynn & Emrich underfeed stokers are described in Bulletin 1105. Flynn & Emrich.

8 **Integral Furnace Boiler**—Bulletin G-17A gives data on integral furnace boiler, either stoker firing or oil burning. Can be converted to burn whichever is the more economical fuel. The Babcock & Wilcox Co.

ELECTRICAL

9 **Electrical Insulating Materials Manual** —Handy 32 pg. file-size manual provides engineers and designers with concise, authoritative data on various types of electrical insulating materials. Headings include: Theory and behavior of dielectrics, mica and mica plate, varnishes, inorganic insulations, properties of insulating materials. William Brand & Co.

10 **Motors and Generators**—New 8 pg. bulletin describes operating features and performance of Burke a-c synchronous motors 1 to 1500 hp., synchronous generators 1 to 1000 hp; also d-c motors and generators, induction motors, terminal blocks. Burke Electric Co.

11 **Electrical Equipment For Food Plants** —Motor and controls, Electric heating units, Laboratory products, Load-center distributing systems, Transformers, Wiring, Air conditioning and Refrigeration equipment and other units for food plants are described in Bulletin GEA-4322. Contains useful charts and diagrams. General Electric Co.

12 **Switchboards and Switchgear**—Described in new 170 pg. catalog is complete line of Pelham switchboards, panelboards, switchgear, fuses, lugs and other accessories. Contains wiring diagrams, motor circuit data, properties of conductors and other handbook data for electrical men. Pelham Electric Mfg. Corp.

13 **Power-Circuit Transformers**—Bulletin 421 tells how power circuit transformers eliminate need for separate complete high and low voltage circuits. Dry type—easily mounted on walls or directly on machines. Jefferson Electric Company.

14 **Sealed Power Motors** — Bulletin just issued by the Crocker-Wheeler Division of Joshua Hendy Iron Works describes its Sealed Power motor. This unit was developed for use in dusty locations, in places where there is excessive moisture, and for all applications where the conventional a-c totally-enclosed, fan-cooled motor has been used in the past. It is available in sizes from 2 to 15 hp.

15 **Motor Conversion Kit**—Free Reconversion Kit covers all makes of electric motors, centrifugal pumps and v-belt drives; gives practical tips on locating trouble, weeding out wartime makeshifts, matching the right unit to each job. Allis-Chalmers Mfg. Co.

16 **Comics Tell Story of Electricity**—A 20 pg. full-color comic book explaining how electricity is generated and distributed has been released by the Allis-Chalmers Mfg. Co. Entitled "Jim's Adventure," the book uses everyday experiences to tell the complex story of electricity. A small boy and his uncle visit a steam generating plant, follow the electric power lines from the station back to the boy's home. A two-page drawing outlines the basic steps in steam and electrical generation and power distribution, from boiler to light switch. Back cover has a brief glossary of common electrical terms.

17 **Formulas For Electrical Engineers**—An 8 pg. folder "Conversion Factors and Formulas for Electrical Engineers" has just been published by the I-T-E Circuit Breaker Co. Contains over 600 conversion factors commonly used by electrical engineers as well as definitions of basic electrical units, prefixes, mensuration and temperature conversion factors. The lists are arranged for use in a loose-leaf binder or for desk or wall mounting. Factor tables have been lacquered to add durability.

FANS, PUMPS, COMPRESSORS

18 **Two Stage Centrifugal Pump**—New Bulletin 381 gives specifications and performance data on American-Marsh two stage single suction centrifugal pumps for boiler feed and general service. Large sectional drawing shows 12 important features. American-Marsh Pumps, Inc.

19 **Vertical Turbine Pumps**—Typical applications of Worthington vertical turbine pumps, plus construction details, are covered in new Bulletin H-450-B33. Pumps are widely used in bored wells, tanks, reservoirs, mine dewatering, oil transfer, etc. Worthington Pump and Machinery Corp.

20 **High Efficiency Compressor**—Bulletin 728 tells about simplate valves, liberal water jackers, one-piece crosshead and other features of CP Type T air compressors in single-stage design for pressures up to 150 lb.; multi-stage units up to 5000 lb. Chicago Pneumatic Tool Co.

21 **How to Solve Pumping Problems**—Bulletin 11-33 with that title, 32-pg. discusses the job of pumping hot and heavy liquids and other pumping problems; also tells about Roper rotary pumps in capacities 1 to 300 gpm, pressures up to 1000 lbs. Geo. D. Roper Corp.

22 **Steam-Jet Air Ejectors**—New 12-pg. reprint of magazine articles tells how steam-jet air ejectors work and how they can be used as trouble forecasters for your power plant. Contains useful charts and diagrams. Worthington Pump and Machinery Corp.

23 **Pump Engineering Problems***—New 416-pg. handbook has factual data on installation and maintenance of pumps. A valuable reference for plant managers, engineers, executives, maintenance men. Economy Pumps, Inc., Hamilton, Ohio.

24 **Know-How Book for Pump Users***—Cameron Pump Operators Book was prepared to help operating men take better care of their centrifugal pumps and help solve their everyday pump problems. All ten chapters are packed with useful data; pocket size; durable fabricoid covering. Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.

*These booklets sent free only in response to requests on business letterheads mailed directly to manufacturer.

INSTRUMENTS AND CONTROLS

25 **Diesel Engine Governing** — Bulletin 01012 explains with non-technical text and diagrams the basic principles of Diesel engine speed governing. Bulletin 01011 gives a glossary of governor terms. Both bulletins will prove helpful to operating engineers. Woodward Governor Co.

26 **Feedwater Regulators**—Bailey Meter Co., 8-pg. bulletin No. 83-C, entitled "Bailey Thermo-Hydraulic Feedwated Regulators," describes improved designs of thermo-hydraulic generators and bellows-operated feedwater regulator valves, suitable for feed lines ranging in size from ¾ to 6 in.

27 **Automatic Controls**—Catalog 600 describes automatic controls for regulating electrically operated equipment in accordance with changes in temperature, pressure, vacuum, fluid level or mechanical movement. Mercoid Corp.

28 **Insulation Tester**—The new U. S. made "Megger" insulation tester, in plastic molded case, and said to have the same ruggedness and accuracy common to all "Megger" instruments, is described in new Bulletin 1735-PE. James G. Biddle Co.

29 **Handbook on Regulators**—Catalog 70 contains eight sections of useful engineering data on reducing valves, temperature regulators, pump governors and sirens. Foster Engineering Co.

30 **Mechanical Flow Meter**—Bulletin 318B tells about the Builders Flowatch recording and totalizing meter for liquids, steam, air and gas. Diagrams show recommended meter hookups under various plant flow conditions. Builders-Providence, Inc.

31 **Centrifugal Control Engine Governor** —New 4-pg. catalog has just been released by the Monarch Governor Co., completely describes a new model of governor for internal combustion engines that is centrifugally controlled; includes installation instructions and parts list and prices. This company now can provide either vacuum or centrifugal type of engine control.

MAINTENANCE MATERIALS

32 **Packing Guide**—Catalog 40 is a valuable packing guide of information on packings for all services. Clearly illustrates and describes various packings of this company; suggests varied packing styles from which to choose a substitute packing. Also provides engineering data and other informative charts. The Belmont Packing & Rubber Co.

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JANUARY, 1946

POWER PLANT ENGINEERING
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33 **Rust-Preventive Oils**—Well illustrated, 40-pg. booklet tells where and how to use Shell rust-preventive oils to lubricate machinery wherever moisture is a factor. Protective coatings range from thin transparent oil films to heavy, abrasion-resistant surfaces. Shell Oil Co.

34 **Oakite-Vapor Cleaning Unit**—Bulletin describes Oakite-Vapor unit, with oil-fired enclosed steam generator that delivers vaporized cleaning solutions under pressures up to 200 lbs. for speedier removal of grease, grit, paint and other deposits. Unit can be made portable; also fitted with two steam guns. Oakite Products Co.

35 **Waterproofing and Leak Sealing Compound**—Booklet describes compound that seals leaks against water pressure—waterproofs walls—seals concrete water tanks or vats. Comes in liquid form and, when added to concrete mortar, sets up quickly—protects against dampness and underground seepage. Flexrock Co.

36 **Floor Maintenance Problems**—Illustrated folder pictures 15 different problems relating to the maintenance of floors and driveways in industrial plants; suggests a specific type of Stonhard for taking care of the ruts, cracks and leaks. Stonhard Co.

37 **Industrial Lubrication Chart**—New chart on Modern Industrial Lubrication contains helpful ideas on lubricating 139 different types of power and production equipment. Should be useful to operating and maintenance men. Adam Cook's Sons, Inc.

MECHANICAL TRANSMISSION

38 **Variable Speed Control**—Here's a small book about a big subject—Variable Speed Control for production machines. Reading time is only 12 minutes. Slipped into your pocket and read on the street car, bus or train, or between conferences, it will give you a quick explanation of the volume-increasing, quality-improving and money-saving advantages of a machine that will operate at exactly the right speed for every changing condition, or job. Reeves Pulley Co.

39 **V-Belt Data Book**—How Veelos link construction provides quick, easy tension adjustment and other advantages in V-belt drives is illustrated in 8-pg. bulletin. Contains sample calculation for engineering a Veelos drive and other useful V-belt information. Manheim Mfg. Belting Co.

40 **Endless Rubber Belts**—Featured by an illustrated step-by-step description of making rubber belts endless by the Plylock method, The B. F. Goodrich Co., has issued a new catalog section of its Plylock Belt Joint. Ends of the plies are interlocked and sunk beneath the surface of the belt by the removal of a short section of the fabric in the second ply, and the resulting depression filled with a reinforced rubber cushion. Then the joint is permanently vulcanized with belt thickness remaining uniform throughout.

41 **Speed Reducer**—4-pg. folder on Bowes Drive, an electric device for speed reduction between modern high-speed prime movers and drive shafts, contains photographs of unit and its component parts, together with description of operation and other data. Elliott Co.

PIPING, VALVES, FITTINGS

42 **Slip Type Expansion Joints**—Applications, features and specifications of Howard slip type expansion joints are covered in new 8-pg. Bulletin XJ-300. Closed guide shell prevents dirt collecting on sliding sleeve. Howard Iron Works.

43 **Air Separator**—Bulletin S-13, 4 pages, describes the combination air separator and trap for users of compressed air tools and operations. Discusses need for clean dry air for the protection of pneumatic equipment. The Swartwout Co.

44 **Valve Repair Record Sheets**—Handy file-size folder contains separate repair and replacement record sheets for gate valves, check valves, globe angle and Y valves. Helps you determine if abnormal service loads have worn valves beyond the point where they can be reconditioned; shows how to keep valves working at top efficiency. Jenkins Bros.

45 **Selection of Safety and Relief Valves**—A complete line of safety and relief valves is described in the new catalog No. 45, just issued by the Farris Engineering Co. A "ready-reference pictorial index chart" shows line drawings of all the basic Farris valve types. With this chart a valve user can pick out the valve he needs without having to thumb through a whole catalog. Directly opposite the pictorial index chart is a detailed index showing what the valve can be used for and where to find its specifications in the catalog.

46 **Forged Steel Unions**—List prices, dimensions and applications of mark forged steel unions are given in new bulletin. These unions will stand severe wrench abuse; have the extra strength that guards against stretching and distortion when being made up and taken down. Clayton Mark & Co.

47 **Handbook on Welding Fittings**—Tables for figuring allowable working pressures for Tube-Turn welding fittings in power, oil, district heating, gas and air, refrigeration piping are given in useful 18-pg. handbook. Tube Turns, Inc.

48 **Quick Operating Valves**—Describing latest developments in level-operated gate valves, a new 16-pg. bulletin, issued by Everlasting Valve Co., shows industrial and process line applications for which these valves are particularly advantageous. Features of these Everlasting valves include quick action, straight-through flow, leak-tight seal and self-grinding of the sealing surfaces.

49 **Valve Chart Tells How to Renew Vital Parts**—A new Valve Renewable Parts Chart has just been published by the Reading-Pratt & Cady Division of the American Chain & Cable Co., Inc. It gives pictures and data on Brass and Iron valves with vital parts that can be renewed, tells how to renew and replace worn-out parts; offers in one-two-three order the facts that should be remembered when ordering new parts. Chart is 22 in. high by 28 in. wide and is printed in two colors, (red and black).

50 **Condenser Tube Protectors**—A new bulletin which describes the John Crane Condenser Tube Protector has just been issued by Crane Packing Co. These condenser tube protectors were developed because most tube failures due to thinning and erosion occur at the inlet ends of the tubes. The tube protestor is made of a special plastic material, is highly resistant to abrasion, and armors the mouth and entrance section of the tube itself. Bulletin is illustrated with typical installations and sectional views.

PRIME MOVERS

51 **Gasoline and Gas Engines**—Pictorial Bulletin No. 317 shows applications of Buffalo gasoline and gas engines in sewage and water works; for fire protection and flood control; industrial lighting and other plants. Buffalo Gasoline Motor Co.

52 **Steam Turbine Lubrication**—Bulletin describes development and application of Gulfcrest Oil WCR, a non-foaming lubricating oil for steam turbines that also has an amazing resistance to oxidation and corrosion. Gulf Oil Corp.

53 **Diesel Engine Jobs**—Bulletin gives dimensions and ratings of Sterling Diesel, gasoline and gas engines; shows typical installations in oil well, pumping station, airports, bridge lift and other fields. Power range 75 to 1800 bhp. Sterling Engine Co.

54 **Steam Engines**—Data book describes operating features of Troy-Engberg steam engines for driving power plant and processing equipment. Troy Engine & Machine Co.

55 **Reports on Diesel Engine Life**—Reports that spotlight the long working life of Diesel engines in terms of owner experience are dramatically presented in Caterpillar Tractor Co.'s new booklet, Long Life-Expectancy. The 16-pg. color publication provides, with word-and-picture stories, a cross-section of owners' engine experiences recorded under the conditions of everyday work in oil drilling, lumber, laundry, dairy, lighting plant and other industries.

WELDING AND METALLIZING

56 **Welding Electrode Application Chart**—"Ampco-Trode Industrial Application Chart" is a 10-pg. bulletin, just issued by Ampco Metal, Inc., listing industries in which Ampco-Trode coated aluminum bronze electrodes have been used, types of proven applications in these fields, and recommended grade of bronze weldrod for each. It is based on our histories and gives the reader quick information regarding the recommended grade of welding electrode to be used in an application in some particular field.

57 **Metallizing Gun**—Attractively illustrated bulletin describes the Metco Type Y metallizing gun. Features include uniform density of coating, ease of operation, low cost operation and maintenance. Has chart on spraying speeds and costs. Metallizing Engineering Co.

58 **Arc Welding Accessories Catalog**—Air Reduction has published an up-to-date price list and catalog of welding accessories. Equipment covered includes: electrode holders, graphite electrodes, welding cable, cable connectors, cable lugs, welding helmets. Section on Airco Heliwelding equipment describes this better method on welding magnesium.

59 **Arc Welding Electrode Guide**—"Arc Welding Electrodes" is a handy 32-pg. guide in the selection of the right electrodes for a specific job; also describes the approved welding procedure for each application. Electrodes are recommended for use on mild steel, alloy steels, low alloy high tensile steels and stainless steels. Other sections are devoted to electrodes for aluminum bronze, aluminum and manganese bronze. Wilson Welder & Wetals Co.

60 **Guide to Everyday Welding**—New 8-pg. booklet titled "Guide to Everyday Welding" is offered as a guide in the selection of the proper type of electrode or gas welding wire to use for welding various types of materials, structure and equipment. Information is arranged in easy-to-find tabular form, indexed by industries, listing types of jobs and equipment on which welding is used, showing character of welds and types of electrodes or gas welding rods for each application. Condensed chart shows physical properties, current recommendations and analysis of weld metal deposit for stainless steel, carbon steel, shielded arc and bare and sub-coated electrodes and gas welding wires. Page Steel & Wire Division, American Chain & Cable Company, Inc.

MISCELLANEOUS

61 **Stainless Steel Data Sheets**—Technical Bulletin No. 33 gives well-organized and useful information on Timken stainless steels for applications requiring corrosion and heat resistance. Many tables and charts on tensile properties, creep strength, temper embrittlement, etc. Steel and Tube Div., The Timken Roller Bearing Co.

62 **Open Steel Flooring and Treads**—Attractively illustrated 16-pg. booklet tells about Bates open steel flooring and treads for power and industrial plants. Extra load-carrying ability, safety, light and ventilation are among advantages of this fillet-welded cross bar construction. Booklet offers many tables and diagrams on flooring. Walter Bates Co., Inc.

63 **Engineering Services**—Booklet outlines the complete engineering service offered in plant design and construction; installation and alteration of process equipment; surveys for reducing production costs; plant appraisals; utilization of by-products, etc. Foster D. Snell, Inc.

64 **Masonry Construction Manual**—Bulletin 810 "Corrosion-Resistant Masonry Material and Construction Manual" is full of helpful facts and suggestions relating to materials and methods of building tanks, towers, sumps, floors and other masonry. A practical reference for plant owners and maintenance men. U. S. Stoneware Co.

65 **Corrosion-Resistant Water Heaters**—Well illustrated bulletin shows construction details and typical installations of corrosion-resistant nickel-clad storage water heaters and tanks. Capacities range from 380 to 2452 gal. Alberger Heater Co.

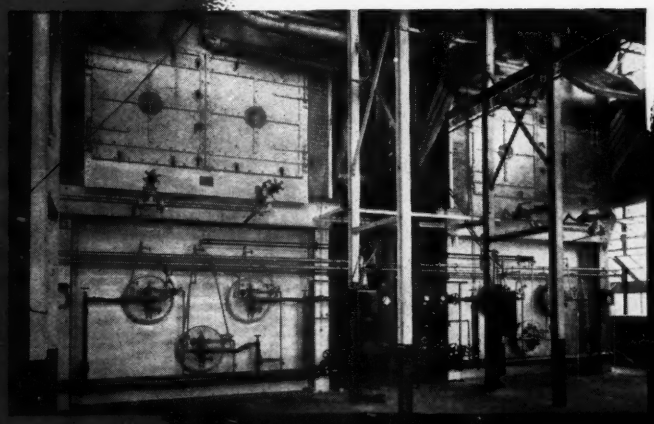
66 **Grab Bucket Cranes**—A new 28-pg. book, describing P&H Grab Bucket Cranes, Has been issued by the Harnischfeger Corp. Construction details are given, and various industrial applications are illustrated. Particularly suited for handling solid fuels and all types of bulk materials, these cranes are widely used in power plants.

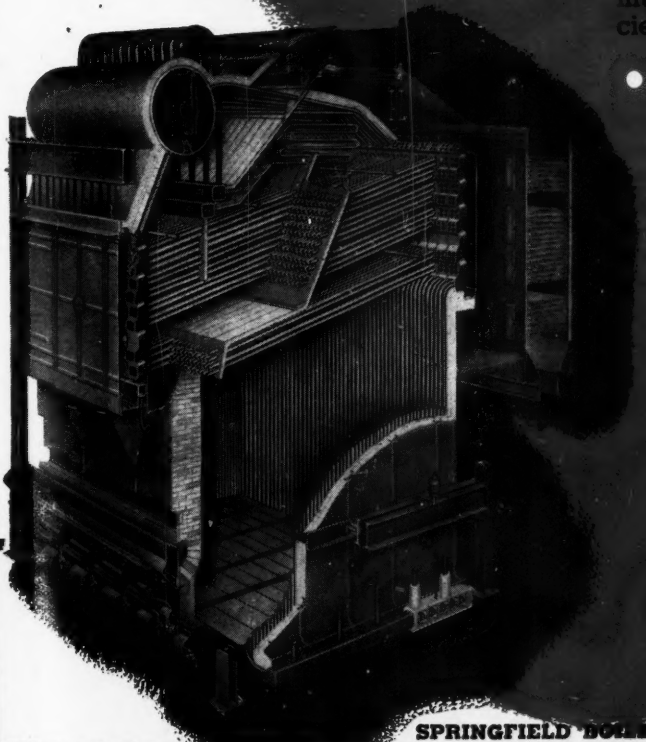
67 **Temperature Exchanger**—Bulletin No. 21 describes the new Bird-White temperature exchanger based on the principle of heat transfer for air and gas lines and offering as a byproduct, external heating applications and positive purification by centrifugal action. When used as an aftercooler, the unit is installed at compressor discharge. Bird-White Co.

68 **Guidebook for Industrial Designers**—A new 12-pg. booklet on rubber and synthetic products created to suggest application of these products to industrial designers has just been published by The B. F. Goodrich Co. Physical and chemical properties of Koroseal are outlined in detail, as well as a large number of uses, also described are: Vibro-Insulators, devices of rubber and metal which reduce vibrations of machinery and the buildings in which they are situated; rubber lined equipment, including tanks and tank cars for handling corrosive acids or algalies, as well as valves, pipes and fittings which serve the same purpose; water-lubricated Cutless rubber bearings; FHP and Multi-V belts, adhesives, sponge, hard and sheet rubber.

Question: WHAT IS AN EFFICIENT STEAM BOILER?

An efficient steam boiler is one that has a high thermal efficiency—one that produces more steam per pound of coal—is easily operated at low cost, and is simple to maintain. If you want the answers to efficiency in a steam generating unit, check the SPRINGFIELD design and constructional features below.





- **Simplicity of over-all design** makes the unit reliable and easy to operate.
- **Staggered group tube arrangement** for maximum heat absorption and high thermal efficiency.
- **Single cross drum** for dry steaming and steady water level.
- **Cast steel boiler headers** (pioneered and developed by Springfield) provide stronger rolled tube joints, stronger headers, and protection against corrosion.
- **Convenient access to all parts** makes maintenance easy.

EXAMINE THIS UNIT. THESE FEATURES GIVE HIGH THERMAL EFFICIENCY: cross flow of gases, multiple pass arrangement, tight baffle construction, small diameter tubes, and efficient staggered tube arrangement.

THESE FEATURES REDUCE MAINTENANCE COSTS: simplicity of design, better header construction, more durable baffles, conservatively designed water walls, and ready accessibility to all parts of the unit.

Write for full information today.

SPRINGFIELD BOILER COMPANY, 1951 E. Capitol Ave., Springfield, Ill.

SPRINGFIELD

STEAM GENERATING UNITS
ANY SIZE — ANY FUEL — ANY PRESSURE

HERE are three stoker designs – each developed to meet a different combination of requirements – which have demonstrated through actual survey, their complete suitability for 90% of all installations covered by C-E contracts of recent years.

These three simplify the problem of stoker selection to one of merely determining which type is the answer to your conditions of steam load, boiler design, and available fuels. With that done, you can be sure of reliable performance, durability, and low maintenance by entrusting your requirements to Combustion Engineering. For embodied in each of these three designs are all the "know how" and experience gained from the installation of nearly 19,000 stokers of every type, above residence size, to serve more than 5,000,000 rated boiler horse power.

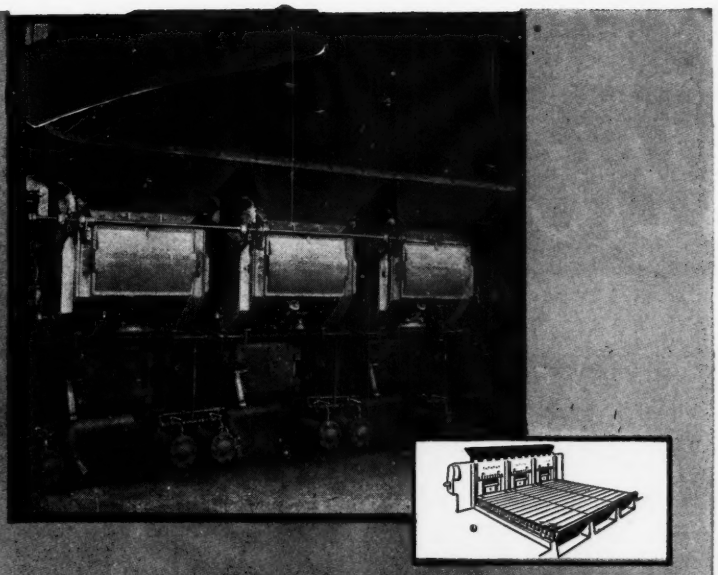
Comprehensive as these three types are, the C-E line includes other designs which round out the most complete line of stokers offered by anybody anywhere. So if your installation falls outside the 90% and within the remaining 10%, you will certainly find the answer to your needs among modern C-E designs of Multiple Retort, Traveling Grate, and Chain Grate Stokers.

It is none too soon to plan your new installation or to modernize your present plant. A C-E engineer will be glad to discuss your problem with you. A-829A

COMBUSTION C-E ENGINEERING

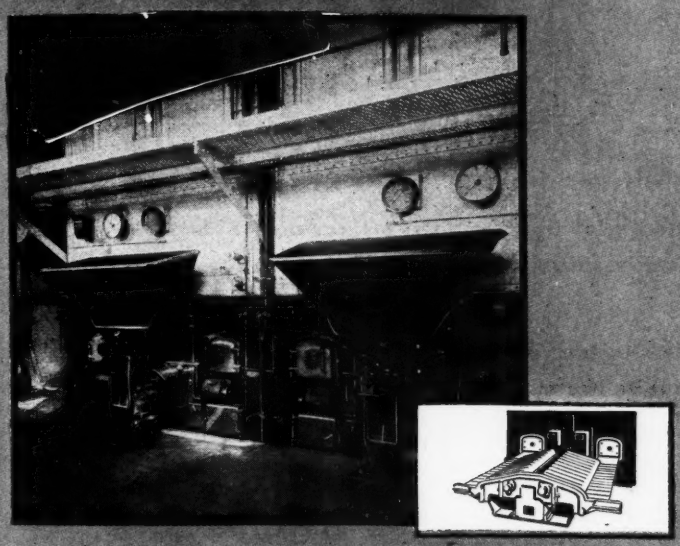
200 MADISON AVENUE · NEW YORK 16, N. Y.

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS



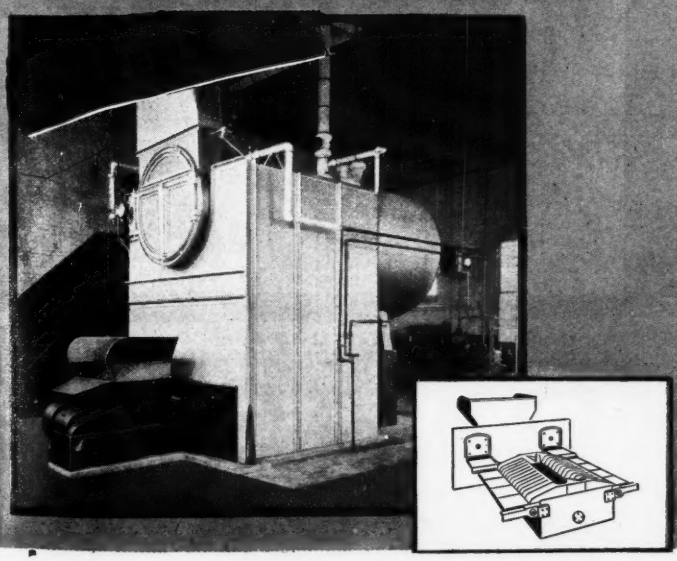
SPREADER — Overfeed

Approximate Application Range — 150 boiler hp to largest units suitable for stoker firing. A simple, rugged stoker designed to burn a wider variety of fuels than any other type of mechanical firing. Hopper, feeding and distributing mechanism, variable-speed drive and motor are combined in a compact unit. Rotating spreader blades feed coal into the furnace in crisscrossing streams which assure uniform distribution. Fines are burned in suspension and the rest of the coal is burned on a grate — stationary or dumping type. Grate surface is zoned for regulating air admission and to facilitate cleaning.



TYPE E — Underfeed

Approximate Application Range — 150 to 600 boiler hp. A single-retort, underfeed stoker designed to burn a wide variety of bituminous coals. Ram feed is supplemented by a reciprocating sliding bottom. Grate surface consists of hollow, air-cooled grate bars, alternately fixed and moving, to condition the fuel bed and assure its steady movement toward the dump trays. Air supply under zoned control with provision for introducing air over the fire. Steam or hydraulic drive.



SKELLY — Underfeed

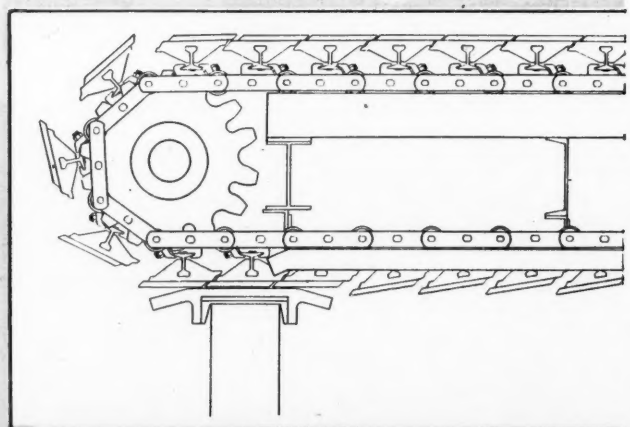
Approximate Application Range — 20 to 200 boiler hp. A compact, self-contained unit offering all the advantages of underfeed firing. Moving grate bars assure lateral distribution of fuel and maintain a clean porous fire. Cantilever dump grates of non-avalanching type simplify ash removal. Integral forced-draft fan, with vortex inlet control, permits positive regulation of air-coal ratio. Sixteen rates of coal feed through variable-speed transmission. Automatic control is standard equipment. Timken bearing equipped. Alemite lubrication throughout.

CONTINUOUS ASH *designed*

SOME OF THE DESIGN FEATURES EXCLUSIVE TO HOFFMAN C-A-D GRATES

- Unique air entry through the lower strand
- Uniform air pressures under all parts of upper strand
- Positive air seals, both front and rear . . . that work
- Effective air seals between grate bar sections
- Minimum heat conductivity from fuel bed to carriage
- Expansion and permanent growth of grate structures due to furnace temperatures are absorbed in expansion joints, provided in the design
- Any expansion in grate structure will not be transmitted to the moving carriage, due to the method of mounting

Firite SPREADER TYPE



HOFFMAN C-A-D grate

HOFFMAN COMBUSTION

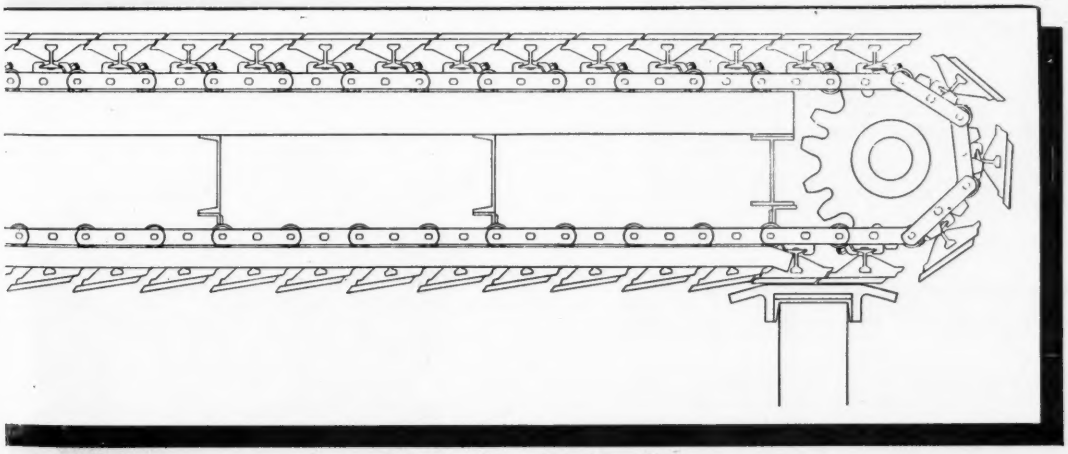
WORKS AT: FAIRMONT, WEST VIRGINIA
DETROIT, MICHIGAN

DISCHARGE GRATES

and built by

HOFFMAN

- Grate and fuel bed load is not carried on chain and sprockets
- Hoffman C-A-D grates may be installed to discharge at either front or rear



Patents allowed and pending

ENGINEERING COMPANY

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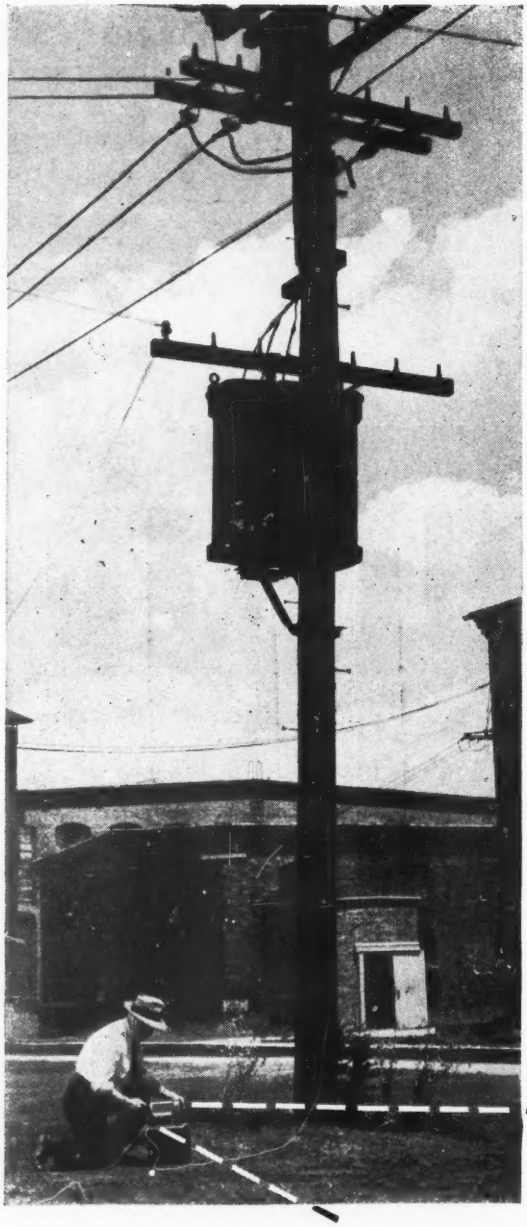
Agents in industrial centers



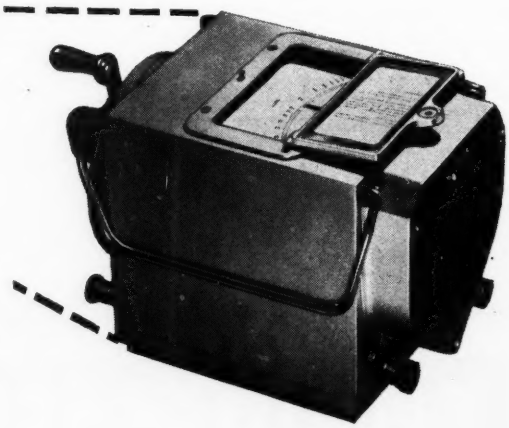
Are you getting protection from your ground connections?

• Ground connections that are improperly installed or have dried out; contacts that have become corroded and loose; exposed metal parts that may become "live" when they should be grounded—all of these can cause trouble when lightning strikes or fault currents develop—can cause injury or death to personnel and material damage to operating equipment.

Know the condition of all your man-made grounds through the periodic use of a "Megger" Ground Tester. These well-known and widely-adopted instruments measure resistance to earth of ground connections, quickly, easily and accurately. Since 1927 they have come into extensive use by power companies, railroads, industrial plants, telephone and telegraph companies everywhere . . . Supplied in both "Megger" and "Meg" types, in various ranges from 0-3 to 0-30,000 ohms.

Order now for your Spring ground testing program.

For a full description of the "Megger" Ground Testers, including the principle of operation, write for Catalog PE.



Some important and valuable features of the "MEGGER"* GROUND TESTER

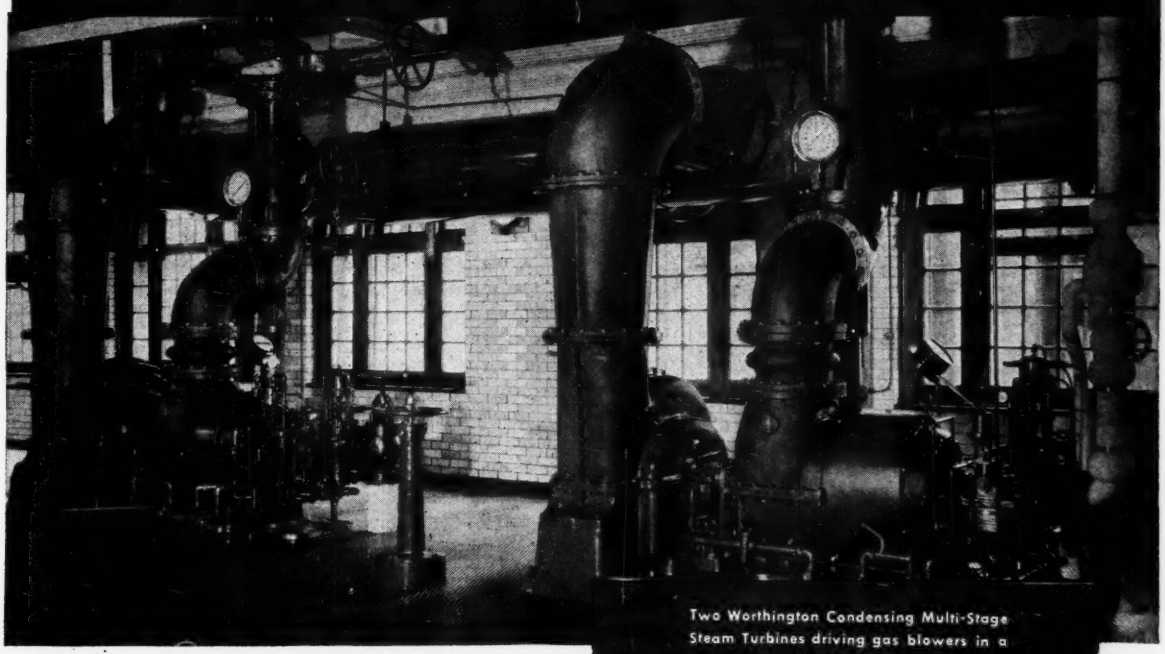
1. *Has its own hand generator; requires no batteries or other external power supply.*
2. *Direct-reading in ohms—"like a voltmeter."*
3. *No calculations.*
4. *Only one set of connections.*
5. *No adjustments or "balancing."*
6. *Unaffected by the exact resistance of the reference grounds.*
7. *Unaffected by stray current in the earth either a-c or d-c, or by polarization or electrolysis.*
8. *Covers a wide range of resistance —0-3 up to 0-30,000 ohms.*
9. *Self-contained, rugged and portable.*
10. *Represents only a small fraction of the cost of adequate grounding protection.*

*T. M. Reg. U. S. Pat. Off.

JAMES G. BIDDLE CO. *1211-13 Arch Street • Philadelphia 7, Penna.*

MORE POWER FROM YOUR STEAM

. . . with Worthington Multi-Stage Turbines



Two Worthington Condensing Multi-Stage Steam Turbines driving gas blowers in a large utility.

You will want to investigate Worthington Multi-Stage Steam Turbines for either condensing or non-condensing service. Worthington's familiarity with all phases of steam power and specialized knowledge of Steam Turbine engineering account for *low maintenance* and *smooth, dependable economic operation.*

Low steam consumption is inherent in the design of these turbines, built in sizes from 100 HP to 10,000 HP for operation on high or low pressure steam and for speeds up to 9000 RPM. For full descriptive literature, write *Worthington Pump and Machinery Corporation, Harrison, N. J.*

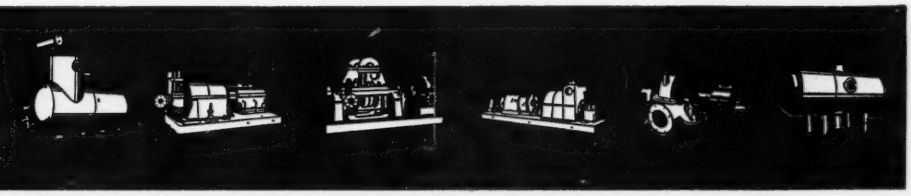
WHO USES THEM?

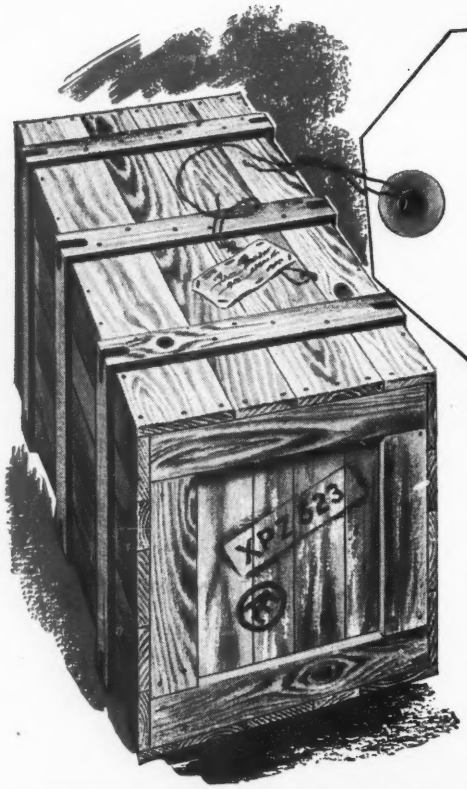
Worthington Multi-Stage Steam Turbines—condensing and non-condensing types — are now driving blowers, generators, pumps, line shafts, refrigeration compressors, air-conditioning units, paper machines, cane shredders, etc. Data that proves *there's more worth in Worthington* is available on request.

WORTHINGTON

T3-1

A GREAT TEAM IN STEAM





CONTENTS— ONE STOKER THAT WON'T CLOG!

IT'S A FACT! The Æ Perfect Spread Stoker hasn't clogged yet. Even when your coal supply is wet or partially frozen, it feeds readily, *steadily*, through a foolproof mechanism to the reliable *overthrow* rotor that spreads a "perfect" fuel bed. Your fuel firing is *safe*guarded by the exclusive Æ non-clog feature, your steam costs reduced because you get more steam from the very lowest grades of coal and solid fuels.

Designed simplicity from hopper to grates and fully automatic operation from a *single* low cost power source brings you greater combustion efficiency and new freedom from fuel worries and maintenance problems. Send for the Æ Perfect Spread Stoker booklet and look into all the advantages to be gained by modernizing your boiler room *now—with the only non-clogging stoker of its kind!*

Æ

PERFECT SPREAD STOKER

WITH STATIONARY GRATES, DUMPING GRATES OR CONTINUOUS ASH DISCHARGE—UP TO 400,000 LBS. OF STEAM PER HR.

Won't Clog on Wet Coal!

Other Æ Products: Æ-Taylor Stokers, Lo-Hed Hoists, Marine Deck Auxiliaries, Hele-Shaw Fluid Power.

IT'S SEASONED IN *EXPERIENCE*

NEW IN PERFORMANCE!

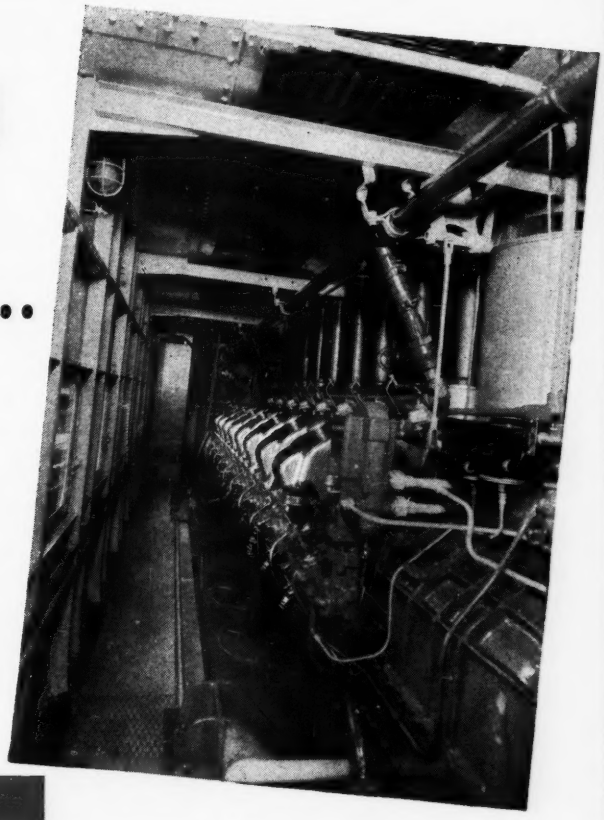
The Perfect Spread Stoker has a record of proved economy—in 15 types of industries—over a 17 year period!

AMERICAN ENGINEERING COMPANY

2408 ARAMINGO AVE., PHILADELPHIA 25, PENNSYLVANIA

LUBRICATION ENGINEERING . . . LUBRICATION ENGINEERING . . . LUBRICATION ENGINEERING . . . LUBRICATION ENGINEERING . . .

Tough enough for break-ins... gives long, clean service



NONPAREIL HD
DIESEL OIL

ENGINE BUILDERS and many operators use Nonpareil HD Diesel Oil as a break-in oil. They find it provides smoother break-ins with no scratching or scuffing of pistons in cylinders. The detergent quality in Nonpareil HD helps remove the finely divided metal particles resulting from wear in the break-in period. The oxidation inhibitor prevents excessive heat, usually accompanying a break-in, from oxidizing the oil to form varnish and other deposits.

These same excellent qualities provide unusual freedom from wear and deposits in continuous operation under heavy-duty service.

The next time you break in an engine use Nonpareil HD—get off to a good start. Then continue to use Nonpareil HD and see how it lowers cleaning and maintenance costs.

Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Ill.

STANDARD OIL COMPANY (INDIANA) STANDARD SERVICE

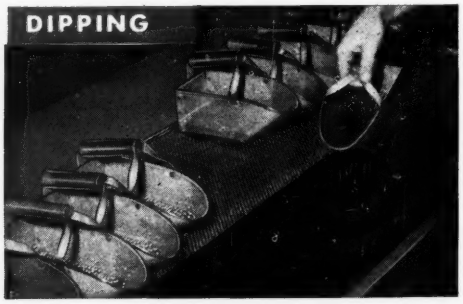
How to get the right rust preventive and the right application

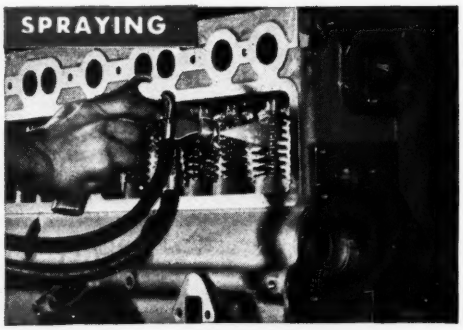
DO YOU WANT help in putting your rust prevention on a more economical basis—one that will assure full protection for parts during production, in storage, or in shipping? Do you want rust prevention that requires the minimum of labor for applying rust-proofing material?

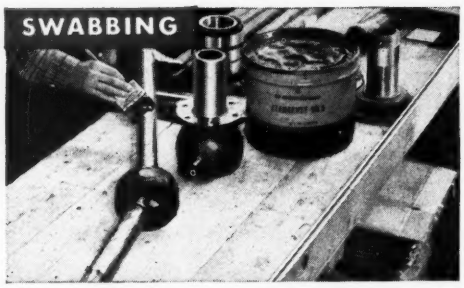
A Standard Oil Lubrication Engineer can give you real help. He has a tested line of rust preventives—Stanorust—plus many of the SR rust preventives approved for use on government equipment. He is familiar with the problems of applying various types of preventives and may be able to suggest shortcuts to save time and labor in your plant.

Put your rust prevention problem up to one of these Engineers. If your plant is in the Middle West, there's one near you. Call the nearest Standard Oil Company (Indiana) office or write, 910 South Michigan Avenue, Chicago 80, Illinois.

STANORUST includes grades for . . .







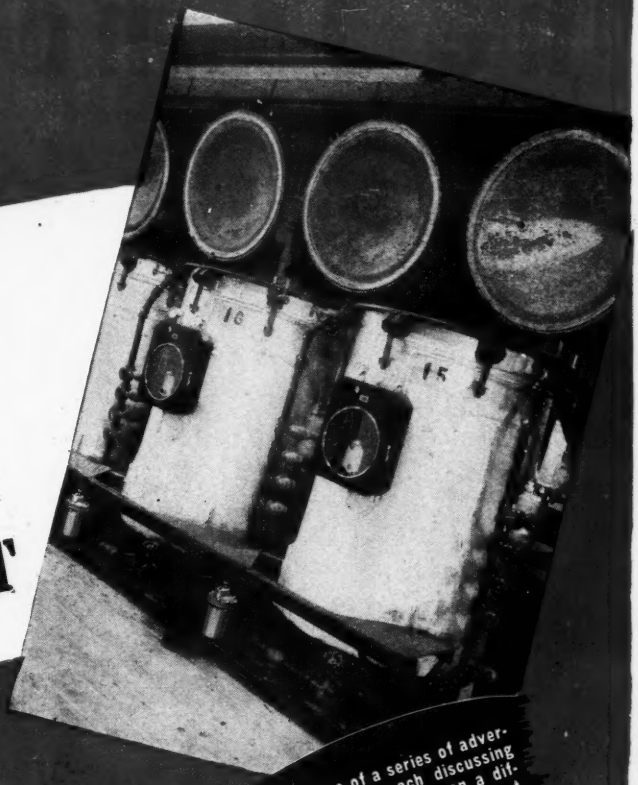
STANDARD OIL COMPANY (INDIANA) STANDARD SERVICE

★ LUBRICATION ENGINEERING

HOW TO TRAP

CHAMBER TYPE HEATING EQUIPMENT

for faster heating

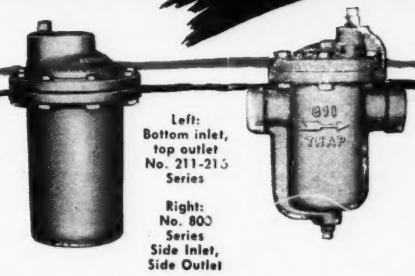


One of a series of advertisements, each discussing trapping practice on a different class of equipment.

Packing Company Cuts Cooking Time 75%!

Chamber type heating equipment must be brought to temperature fast, with no condensate accumulation, and temperatures must be sufficiently high. There are many other requirements, such as ability to operate under widely fluctuating supply line pressures, but Armstrong's ability to meet these difficult requirements is attested to by reports such as the one from a Chicago, Illinois packing plant, where trapping of each cooking kettle reduced cooking time of soybeans from 40 minutes to only 10 minutes—a saving in time of 75%!

Armstrong trap design and construction eliminates all steam leakage, removes condensate as fast as it forms, discharges large volumes of air (500 to 1500 cu. ft. per hr.) and permits operation on an unusually wide range of pressures (1 to 250 lbs.) ARMSTRONG MACHINE WORKS, 810 Maple St., Three Rivers, Michigan.



Left: Bottom inlet, top outlet No. 211-215 Series

Right: No. 800 Series Side Inlet, Side Outlet

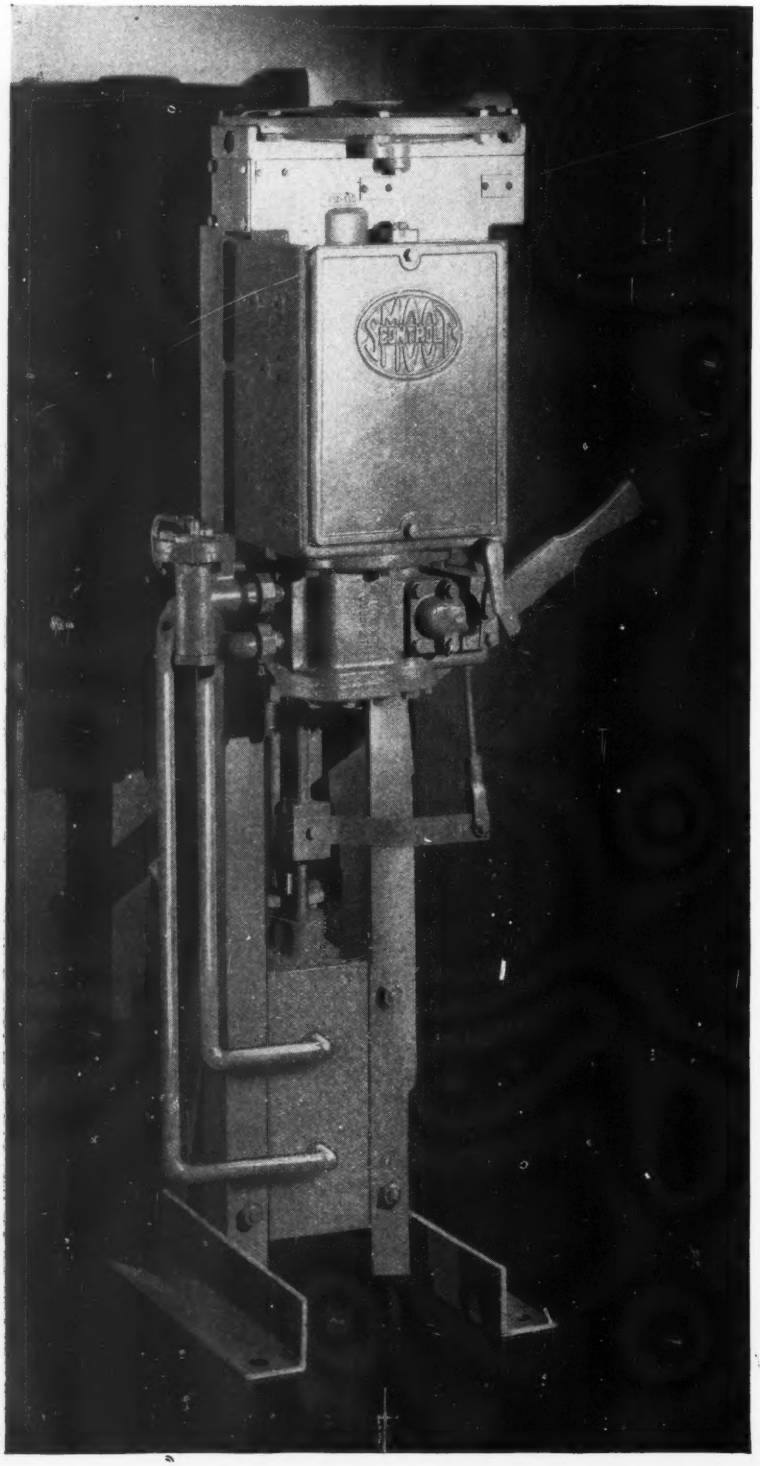
Trapping Tips

- For fastest heating, use Armstrong trap with thermic vent
- Use one trap for each unit drained
- Install trap close to and below unit
- Use ample size steam supply and return lines
- Check the Armstrong Steam Trap Book for valuable information on installation, selection, maintenance and repair of Armstrong traps.

ARMSTRONG Inverted Bucket STEAM TRAPS

Over a Million in Use...For Power...Process...Heating

The Trend is to...



REPUBLIC REGULATOR APPLICATIONS

Pressure Control

Steam pressure control
Boiler furnace draft
Primary air pressure
Feed water pressure
Evaporator pressure
Process steam pressure
Blast air pressure
Exhauster suction
Fuel gas pressure
Suction main pressure
Excess pressure

Flow Control

Water flow to desuperheaters
Water flow to condensers
Oil flow to boilers and furnaces
Gas flow to boilers and furnaces
Air flow to gas producers
Pump bypass

Level Control

Hot well levels
Surge tank levels
Storage tank levels
Evaporator levels
Boiler water levels

Speed Control

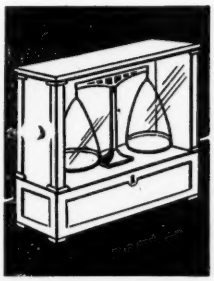
Stoker and fuel feeder speeds
Pulverizer speed
Pump speed
Fan speed
Steam turbine speed
Steam engine speed
Variable speed motors
Variable speed transmissions

View of a Republic hydraulic type regulator for controlling boiler air flow, mounted on stand with power cylinder.

REPUBLIC
INSTRUMENTS
AND CONTROLS

REPUBLIC Regulators

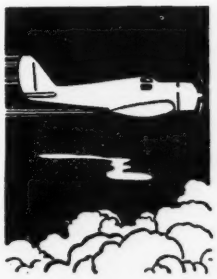
Because They Meet These Four Essentials of Good Regulation



Republic Regulators can be made sensitive to changes of less than 0.002 of an inch of water.

SENSITIVITY

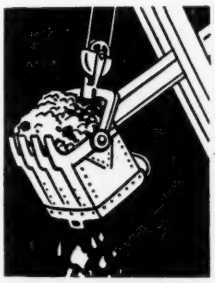
The amount of change that is required in the quantity being controlled to effect the regulator is the measure of its sensitivity. For close, accurate regulation, a regulator must be sensitive. It must respond immediately to the slightest deviation from the predetermined setting or the controlled quantity may vary far beyond the permissible limits.



Republic Regulators will meet any speed requirement up to one full stroke in 2 seconds.

SPEED

The speed at which a regulator operates is an important factor in any control system. Any time lag between the variations in the controlled quantity and the operation of the control device to correct this variation, will produce an unnecessary error in regulation. A regulator, therefore, must be fast enough to follow the fastest load fluctuation.



Republic power cylinders are available to meet the specific power requirements of any particular installation.

POWER

A regulator must have sufficient power to not only operate the valve or other control device, but also to overcome any accidental friction or sticking that may occur in any part of the system. Insufficient power will cause failure in operation. It is for this reason that regulators are made with different size power cylinders, the smaller sizes being used for small valves and the larger sizes for the larger dampers and louvers.

The Republic stabilizer will stabilize against any time lag in the operation of the equipment being controlled.

STABILITY

Stability refers to the ability of a regulator to maintain its balanced position or to return immediately to a balanced position if the controlled quantity is disturbed. There is always an interval between the time the valve or other control device is moved and the time the controlled quantity changes in response to this movement. Unless a regulator is stabilized it will tend to "hunt" or overtravel causing unnecessary variations.

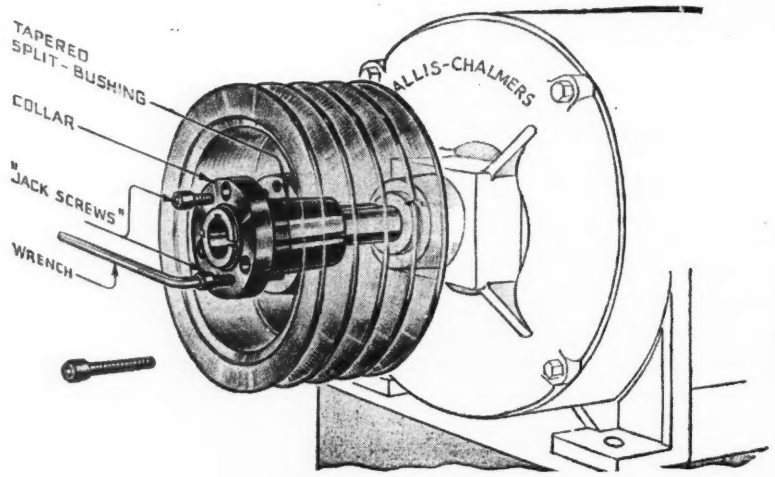
Write for Data Book No. S-13

Republic Flow Meters Co.

2224 Diversey Parkway • Chicago 47, Illinois

It's Easy to See

THE SECRET OF THE "MAGIC-GRIP" SHEAVE



Fastest mounting and demounting sheave on the market, the new "Magic-Grip" costs you nothing extra.

SEE HOW THIS SHEAVE REMOVES EASILY, SAVES TIME AND MONEY

1 **Remove three capscrews** from bushing collar with handy wrench. Insert two capscrews. When turned, they become levers... automatically breaking the tight grip of tapered split bushing on both sheave and shaft.

2 **Remove sheave from shaft.** Requires no mallet, no prying, no bulging muscles. You just slide the sheave off... smoothly, quickly. *It costs nothing extra!* Send for B6310. Allis-Chalmers, Milwaukee 1, Wis.

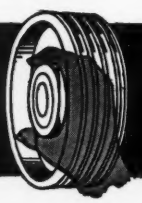
RECONVERTING?

GET THIS NEW FREE KIT!

To help you find out how your present equipment will fit into future production, A-C offers a new free "Reconversion Inventory Kit" — Fact Sheets and Check Lists to speed your appraisal of V-belt drives, electric motors, and centrifugal pumps. Applies to all makes. Call your A-C distributor or district office, or write Dept. 19, ALLIS-CHALMERS MFG., Milwaukee 1, Wisconsin.

A 1859

Allis-Chalmers Texrope

"MAGIC-GRIP"  **SHEAVES**

HEAR THE BOSTON SYMPHONY: *Saturday, American Broadcasting Co.*

Now UP TO 2000 hp!

STANDARD 2000-HP TRI CLAD MOTORS NOW AVAILABLE

THEY GIVE EXTRA PROTECTION 3 ways

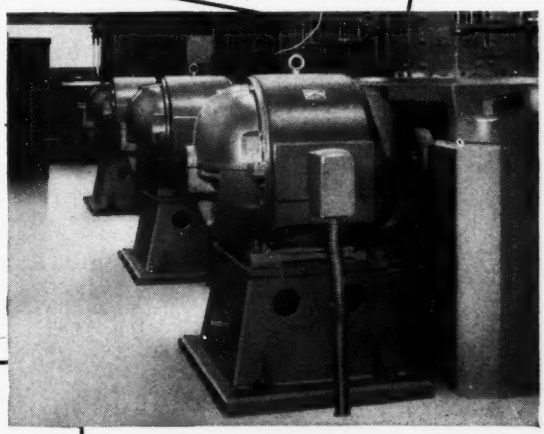
1 **Extra protection from physical damage**—Cast-iron construction. Upper portion completely enclosed. Streamline, cast-iron end shields. Corrosion-resisting finish.

2 **Extra protection from electrical breakdown**—Windings of Formex* wire, strongly bonded with oil- and moisture-resistant synthetic resins, stand up under abrasion or "heat-shock."

3 **Extra protection from operating wear and tear**—Sleeve or ball bearings, in dust-tight housings. Sleeve-bearing design is a further refinement of well-proved Tri-Clad bearing proportions, with cast-in "air seal" to further insure oil tightness of the housing.

The triple-protected construction that has made General Electric's Tri-Clad motor so popular in the small and intermediate sizes has now been extended to motors of 2000-hp capacity. On your *big* drives, these new Tri-Clad motors will meet severe conditions with greater assurance than ever of dependable service and long life.

The Tri-Clad motor, in its wide range of types and sizes, is industry's most popular integral-hp motor. Chances are there's a standard Tri-Clad to meet your requirements "on the nose." For information on G.E.'s complete line of Tri-Clad motors, ask for Bulletin GEA-3580. *General Electric Company, Schenectady 5, N. Y.*



Three of the new, large Tri-Clad motors, each rated 200 hp, 1200 rpm, driving coal pulverizers in a Southern steam-electric plant

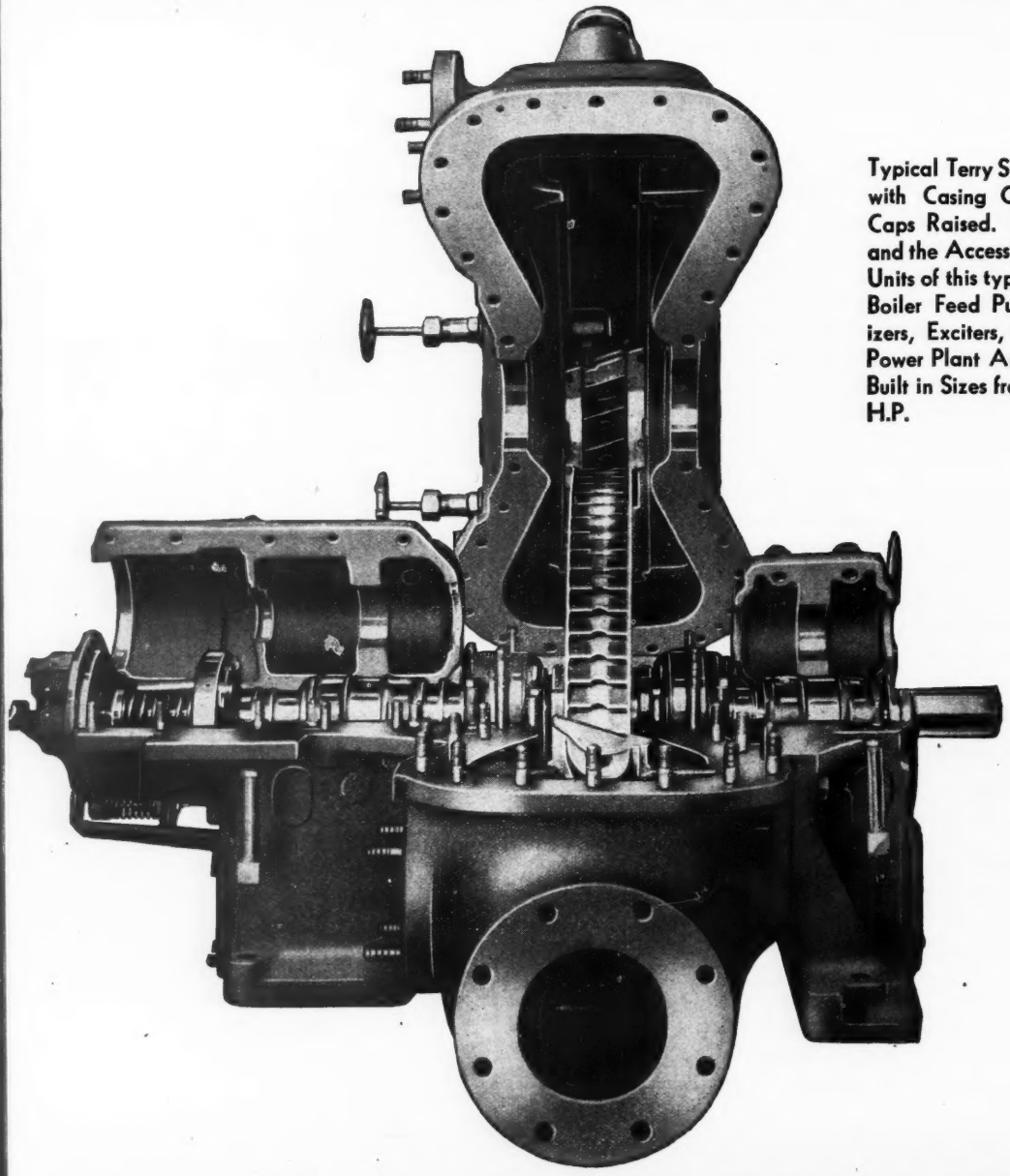
*Trade-mark reg. U.S. Pat. Off.

HERE'S TODAY'S WIDER RANGE OF STANDARD SIZES	
TRI CLAD Type K	—1 hp to 2000 hp at 1800 rpm
TRI CLAD Type KG (High starting torque, low starting current)	—5 hp to 200 hp at 1800 rpm
TRI CLAD Type KR (High starting torque, high slip)	—Available to 100 hp in speeds required for high-slip, flywheel drive (punch press, etc.)

GENERAL ELECTRIC

The TERRY

FOR AUXILIARY DRIVE



Typical Terry Solid Wheel Turbine with Casing Cover and Bearing Caps Raised. Note Ruggedness and the Accessibility of All Parts. Units of this type are used to drive Boiler Feed Pumps, Coal Pulverizers, Exciters, and All Types of Power Plant Auxiliary Equipment Built in Sizes from 5 H.P. to 2000 H.P.

THE TERRY STEAM TURBINE CO.

Wheel Turbine

OFFERS MANY ADVANTAGES

FROM THE SMALLEST TO THE LARGEST, THESE RELIABLE TURBINES HAVE —

- Indestructible One Piece Wheel
- Large Radial and Axial Clearance
- Double Rim Protected Blading
- Dependable and Durable Governor
- Heavy Dust-Proof Bearing and Governor Housing
- Independent Overspeed Trip with Separate Valve
- Sturdy Casing Design
- Strong and Easily Inspected Steam Strainer
- Sight Oil Level Gauges
- Individual Nozzle Control
- Truly Accessible Construction, Which Makes Inspection of the Interior Parts a Simple Matter

For Full Details ask for Bulletin S-116

Action of steam in Terry wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket in which its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

T-1164

TERRY SQUARE - HARTFORD, CONN.

Blazing THE

. . DESIGN FOR 1000°F.

TEMPERATURE CONTROL . . .

Final steam temperature control with an all-convection type superheater invariably requires a compromise between two limiting conditions.

FIRST—when furnace exit temperatures to the superheater are high enough to obtain the desired control range, slagging of the boiler and superheater surfaces may result.

SECOND—when gas temperatures to the superheater are low enough to prevent slagging, the desired control range cannot be met.

The necessity for compromise can be eliminated by using a combination radiant and convection type superheater. Slagging in the boiler and superheater can be eliminated and a high final steam temperature maintained over a wide load range.

FOSTER

ENGINEERING TRAIL

FINAL STEAM TEMPERATURE

FIRST . . .

The first high pressure public utility steam generating unit designed for 1000°F. final steam temperature will go into service during 1946 at the Atlantic City, N. J. station of the Atlantic City Electric Company. Capacity is 310,000 lb. steam per hour at a pressure of 1550 psi. This marks another milestone in design progress for high-pressure, high-temperature steam generating units.

PROBLEM . . .

The engineering problem here was to design a superheater which could deliver steam at 1000°F. final temperature over a wide load range, and in addition, satisfy the second condition of slag-free operation.

SATISFYING BOTH CONDITIONS . . .

The Foster Wheeler combination radiant and convection type superheater satisfies both requirements. Offsetting characteristics of the two superheater types balance to yield an almost constant final steam temperature over a wide load range. As the load increases the steam temperature from the radiant section decreases, while temperature from the convection section increases. Condenser type control provides what regulation is necessary to maintain a steady 1000° over the load range of 130,000 lb. to 310,000 lb. steam per hour.

The second condition—freedom from slagging—is the resut of combining radiant and convection heat-absorbing surfaces, permitting the specified temperature of 1000° to be obtained, while furnace exit temperatures to the convection superheater are kept below the slagging point.

FOSTER WHEELER CORPORATION
165 Broadway • New York 6, N. Y.

WHEELER FW

HAGAN
HALL
BUROMIN
CALGON

Five years

without tube trouble

since starting Hall Service

Water conditioning reports indicated that the desired boiler water conditions had been satisfactorily maintained; the boilers were in excellent condition, and there had been no special problems or difficulties since the Hall engineer's last visit.

Nevertheless, the chief engineer of the plant reported one complaint.

"The refractories salesman," he told us, "thinks we're giving our insulation and refractory cement business to one of his competitors."

Then he told us the story. The salesman had actually come to them with that complaint, when a check of the records showed that they had bought nothing from him for five years, although before that time they had been one of his best customers.

That set the chief engineer to checking *his* records. True enough, they had once been good customers. They had averaged one side-wall tube blister or rupture every week, and, in replacing the tube a certain amount of brick work had to be replaced.

After Hall System was instituted, tube trouble continued only for a short time—then *for the last five years there had not been a single difficulty of this kind.*

Reduction in repairs is only one of the many benefits of Hall Service, only one of the reasons why *every plant that generates its own steam can profit by Hall Service.* Our engineers will be glad to give you full information.

HALL LABORATORIES, INC.

Hagan Building Pittsburgh 30, Penna.

HALL SYSTEM *of Boiler Water Conditioning*

Tops FOR TOP PRESSURES

On steam lines where pressures go as high as 1500 psi, and temperatures up to 900° F. are encountered, steam traps must be rugged . . . and *efficient!*

That's why so many public utilities and other high pressure steam plants are installing Yarway Integral Strainer Impulse Steam Traps. First cousin to the famous standard Yarway Impulse Steam Trap, the integral strainer trap has been developed especially to meet high pressure trapping requirements.

It has ample condensate capacity when system is being "warmed up." Yet it will handle relatively small amounts of condensate efficiently without losing prime. The valve closes positively in the presence of dry or superheated steam.

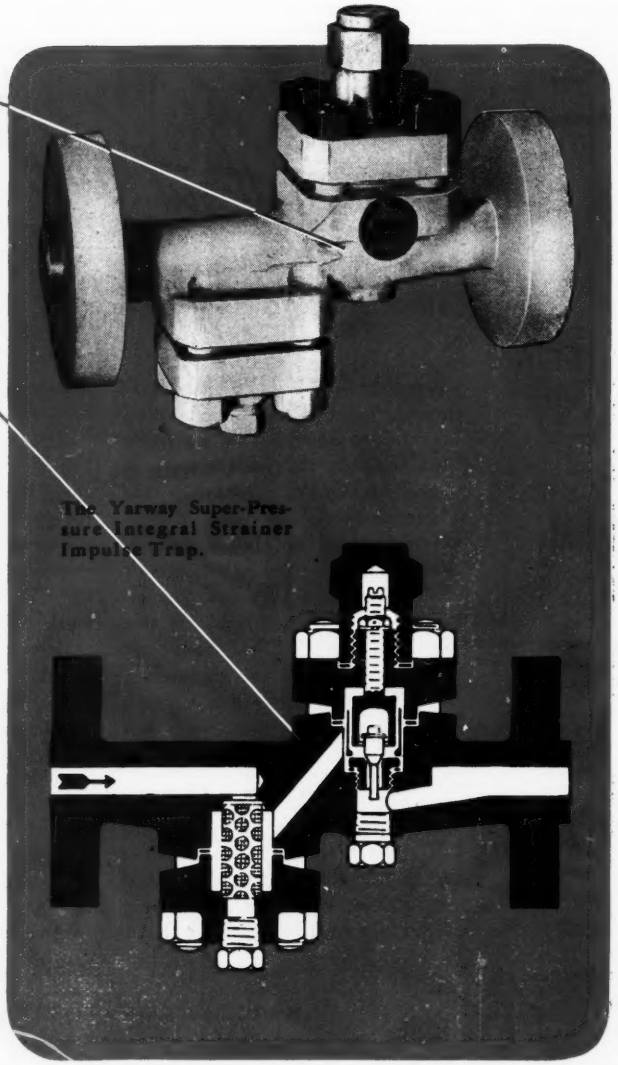
It is a fraction of the size and weight of other type traps designed for the same service—saving space simplifying installation and requiring no supports.

It is suitable for all pressures within a wide range without change of valve or seat.

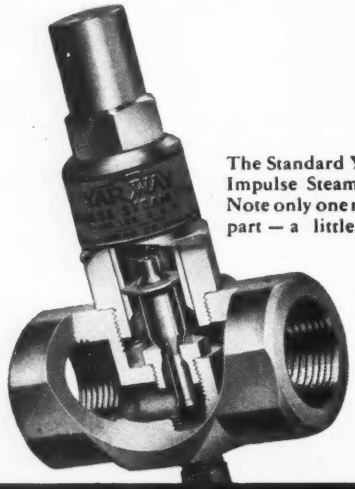
It has the same simplicity of design as does the standard Impulse Trap shown below—only one moving part, the same little valve.

Its integral strainer protects trap against scale and rust in the piping system.

Available with flanged or socket weld connections. Write for Bulletin T-1739.



The Yarway Super-Pressure Integral Strainer Impulse Trap.



The Standard Yarway Impulse Steam Trap. Note only one moving part — a little valve.

See these traps and other Yarway steam plant equipment . . . hear their operation described by Lowell Thomas in the Yarway color motion picture, "There Is An Engineering Reason." Available without charge for group showings. Write today.

YARNALL-WARING COMPANY
114 Mermaid Ave., Philadelphia 18, Pa.

YARWAY IMPULSE STEAM TRAP

WHAT LEADERS SAY

RFC Help for Small Business

By CHARLES B. HENDERSON

"FOR the purpose of maintaining and promoting the economic stability of the country or encouraging the employment of labor. . . ." Those are the words in the Act by which Congress created the Reconstruction Finance Corporation. Though these words were more than significant in the depression days when RFC was born, they have even greater meaning now. For, with the problems of peace in the headlines, RFC's guiding policy ties into action to create full employment and a consistently high national income. Toward this goal RFC is particularly concerned with two aspects of the total problem:

Every means that will bring gainful employment to any portion of the fourteen million men and women who are now or have been a part of our armed forces must be utilized.

Small enterprises must be assured that the credit needed for them to continue will be available.

Practically, the job boils down to a program—one in which Americans have a very real interest. Right now we are geared to make loans for civilian production. We are able and willing to finance plant and equipment reconversion, to finance new equipment and plant purchases and to finance surplus property and surplus equipment purchases. We are making business loans to returning veterans under our own veterans' loan program. Not only are we performing our own function in this all-important matter of financing returning soldiers, but we are tooled to tie in with special programs as they are requested by the Veterans Administration under the Servicemen's Readjustment Business Loan Program. Finaly, we are making commitments now for the future, so that business may proceed with plans for rehabilitation and reconversion, certain that when funds are needed they will be available.

Under the law RFC can make loans only when "capital or credit, at prevailing rates for the character of loan applied for, is not otherwise available." In effect that means that the borrower, when he comes to RFC, has already found he cannot get the financial help he needs from regular banking sources. That fruitless search must have taken time and since he needed the money when he started his quest, the chances are that his need is dire when he applies to RFC. He must get action fast. To bury him in red tape and questionnaires may be to kill him off as a business man, just when the country needs his enterprise most. Decisions must be made quickly and RFC's local offices are far from sufficient. The man in the country and the small town may need help as much and as fast. This is where the local bank comes in.

Recently RFC authorized what is called a blanket participation agreement. This agreement authorizes a local bank to make secured loans not to exceed $250,000 to a borrower, up to a ten-year period, with RFC insuring up to 75% of the risk. Under this arrangement any approved bank is permitted to make immediate loans according to the bank's own judgment and without requiring initial approval by RFC (except as to salaries paid by the borrower which is a requirement of the RFC Act). The effect of the agreement is to permit banks to take more risk than they would ordinarily take. It enables banks to do quickly things which previously they rarely could do at all because of their responsibility to their depositors and their stockholders.

The first duty of a bank is to its depositors, while to RFC the over-all economy of the nation is the primary interest, which explains the bank's limitations and RFC's role in assuming a greater risk. Banks cannot afford to tie up too much of their money in long-term loans. Small business, to survive, needs long-term loans, therefore RFC must fill the gap. Banks are limited as to the amount of funds they can make available to individual borrowers. RFC thinks not only of the individual, but of the country. As part of the Government RFC can and must think in terms that are broader than the bank's horizon. The matter of employment is a definite Government obligation. The problem of keeping business on an even keel, even at the risk of some loans going bad, is a definite Government function. The question of advancing money for intermediate term or long-term loans is less onerous upon the Government than upon banks. In short, the Government, operating in the interest of 135,000,000 persons, naturally takes a broader range view than a commercial bank which numbers its depositors in the thousands.

Lending as far as RFC is concerned is not a matter of "blue chip" collateral, of endless investigation or of ultra-conservative safety. RFC wants loans which will be paid back, of course, and it will protect the money of the people of the United States—but the stability of our over-all economy must guide our activities.

What RFC is doing and is prepared to do for small business is not generally known. Over 20,000 loans of $100,000 or under have been authorized by it to small business.

This is contrary to a general impression that RFC makes loans only to the big fellow. Of course, it is easier to do business that way, but whatever the temptation to take an easy out, RFC is never unmindful of the responsibility placed upon it by Congress to provide financial help to the small business man who is unable to obtain credit through the usual banking channels. To achieve that goal RFC will put all the time and energy which is required into efforts to help the small man. He is the indispensable man if the goal of full employment is to be realized.

RFC knows that no one group can cure the financial problems of small business. Any real solution needs the considered efforts of the Government and private organizations working together in close harmony. RFC's support of the banks of the country in a program of sound long-term credit, the kind of credit small business finds it most difficult to get, is part and parcel of the whole.

Charles B. Henderson, Chairman of the Board of the Reconstruction Finance Corporation, is a graduate of the University of Michigan. A lawyer, he began practice at Elko, Nevada, 1896. He was elected as District Attorney of Elko County, Nevada, served until elected to the Navada legislature in 1905. On the expiration of his legislative term he became a regent of the University of Nevada. Later, January 4, 1918, he was appointed a member of the United States Senate by Governor Emmet D. Boyle to fill a vacancy caused by the death of Sen. Francis G. Newland. In November, 1918, Sen. Richardson was elected to fill the unexpired senatorial term ending in 1921. In 1934 he was designated member of the Board of Directors of the Reconstruction Finance Corporation and in 1941 became Chairman of the Board.

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BOILER MAINTENANCE IN LARGE BOILER PLANTS

This article although it deals specifically with the boiler maintenance at the James H. Reed and Brunot Island Power Stations of the Duquesne Light Company in Pittsburgh should be of value to operators in other large boiler plants of a similar nature. It describes in detail maintenance procedure in regard to such things as tube leakage, soot and dust removal, etc. It covers the inspection, maintenance and repair of stokers, pulverizers, air preheaters, fans, ash handling equipment, sootblowers, and of course, the boiler itself. Written by the boiler engineer himself, the article is practical in every respect.

By E. W. Gardiner *Boiler Engineer, Duquesne Light Company, Pittsburgh, Pa.*

THE DUQUESNE LIGHT COMPANY in Pittsburgh, Pennsylvania, has four major steam electric generating stations, Frank R. Phillips, James H. Reed, Colfax, and Brunot Island, the total rated capacity of which is 619,000 kw. The steam conditions at these stations vary from 175 psi and 475F at Brunot Island to 850 psi and 900F at Frank R. Phillips. The boilers vary in size from the smallest at Brunot Island, the output of which is 23,000 lb. per hour, to the largest at Phillips, the output of which is 500,000 lb. per hour. The boilers installed in these stations are capable of generating a total of about eight and three-quarter million pounds of steam per hour.

To insure the dependability of electric service required by the public, boiler room equipment must be kept in first class operating condition. If the boilers failed to deliver the required quantity of steam to meet the demand of the turbo-generators every instant of the day, service to the customers would be curtailed proportionally to the extent to which the boilers failed. Besides furnishing the required quantity of steam, the boilers must generate it as economically as their design will permit. In other words, they must make the most steam with the least coal and the fewest breakdowns possible. It is the job of the boiler maintenance crew to keep boiler room equipment in such condition that these requirements can be satisfied.

The boiler maintenance problems will vary with the boiler equipment installed. The maintenance as presented in this article will be concerned only with the boiler equipment in the James H. Reed and Brunot Island Stations both of which are located on Brunot Island in the Ohio River about 1½ miles from the downtown district in the City of Pittsburgh.

The James H. Reed station which was placed in operation in 1930 has a total installed capacity of 180,000 kw, consisting of six boilers and three turbo-generator units. The boilers are Babcock and Wilcox Stirling type, fired by Westinghouse underfeed, linkgrate stokers with water-submerged, clinker grinders. The turbo generators are 60,000 kw, single cylinder machines with 400 psi and 750F steam at the turbine throttles.

Fig. 1. The Boiler Maintenance Group 1st row. Left to right: P. DeCarpio, R. Kyle, W. Cooper, L. Olander, W. Henderson, and A. Capalonga

2nd row: E. W. Gardiner (Boiler Engineer, author of this article), R. Barkley, A. Covne, J. Cassandro, N. Salicce, N. Melnick, K. Marti, H. Longmore, and A. Stocchi

3rd row: J. Kikta, F. Stadler, H. Staub, R. Walsh, W. Harlan, A. P. Covone, J. Hodder, and M. Ranker

4th row: W. Wiley, F. Mascaro, A. Walker, F. Kozlowski, P. Balogh, R. Watson, and J. M. Black

5th row: E. Harley, J. Dougherty, H. Grove, W. Burns, W. Reith, and T. Geddis

The Brunot Island Station was placed in operation in 1902 and now has a total installed capacity of 116,500 kw, consisting of 55 boilers and six turbo generator units. Nineteen of the boilers are fired by Murphy underfeed stokers, 17 are fired by Westinghouse underfeed stokers with dump grates, 10 are fired by Green chain-grate stokers and 9 are fired by pulverized coal.

The six large boilers in the Reed Station are of modern design compared to the boilers in the Brunot Island Station and are capable of generating a slightly greater total quantity of steam at higher pressure and temperature, which in conjunction with more efficient turbo-generators gives the Reed boiler group considerably greater power generating capacity than Brunot Island.

The boiler rooms in these stations also include auxiliary equipment such as forced-draft fans, induced-draft fans, stokers, pulverizers, boiler feed pumps, economizers, air preheaters, clinker grinders, ash hoppers and ash sluice systems, feedwater heaters, etc.

Due to the James H. Reed and Brunot Island Stations being located adjacent to each other on Brunot Island, they are manned by an organization which functions as a unit common to both stations. The boiler maintenance crew employed in everyday routine boiler maintenance in these two stations includes about 40 men. In this group are several grades of boiler repairmen, welders, pipe fitters, bricklayers, pipe coverers, furnace cleaners, helpers and laborers who perform duties representing a considerable variety of specialized skills related to boiler plant maintenance only.

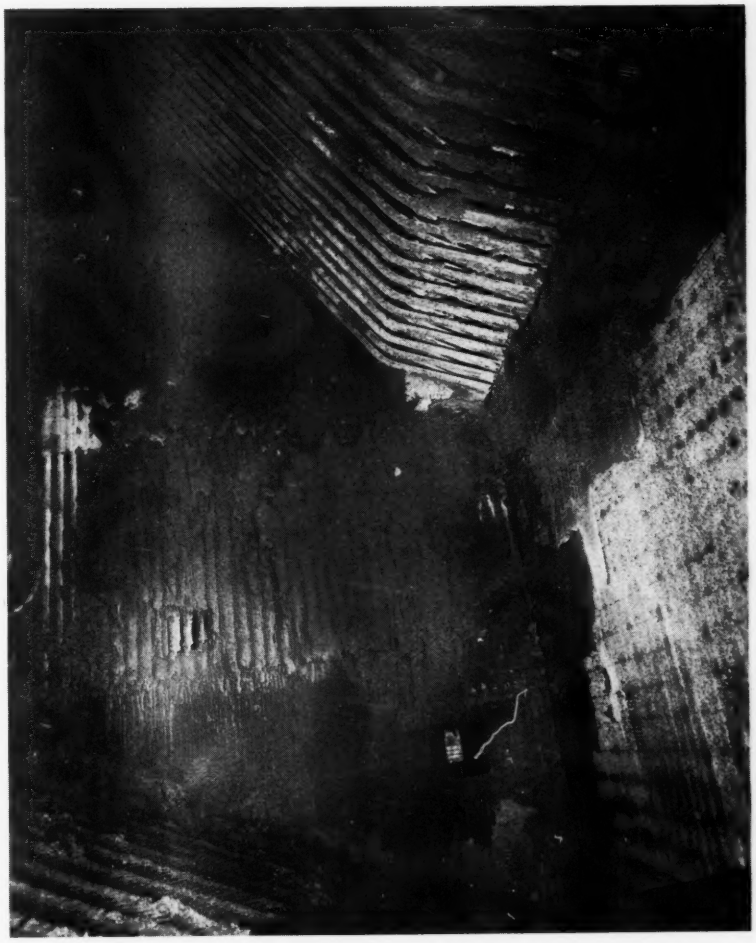


Fig. 2. James H. Reed boiler furnace before cleaning, showing lower bank of boiler tubes at top of picture, side wall tubes straight ahead, and stoker tuyeres at bottom

Boilers

One of the largest single items of attention required to keep the boilers in good operating condition is to keep them clean, internally and externally, so as to maintain good transfer of heat through heating surfaces and insure proper circulation of water in the boiler. The problem of keeping internal surfaces clean and scale free, which was a big problem in the "Good Old Days" has been almost completely solved by modern practices of evaporating make-up water and chemical treatment of boiler water, so that the present day cleaning problem has been boiled down mostly to external cleaning of heating surfaces only.

Furnace walls and external heating surfaces of the boiler tubes become coated and gas passages become fouled with deposits varying from hard, stone-like slag to scaly, dusty deposits. This material all originates from the coal being burned, the hard slag representing accumulations of chilled, molten ash particles blown from the fire, and the dust representing particles of ash and unburned fuel carried from the fire into the boiler gas passages. The hard heavy slag deposits are always found on furnace walls and in gas passages close to the furnace while the scaly and dusty deposits are found in the passages in the rear or cooler parts of the boiler.

The boilers are equipped with sootblowers which function to blow deposits from the tubes with steam jets while the boiler is in operation. The sootblowers referred to are the standard, conventional type which aid in keeping the boilers clean by removing some of the dust deposits, but the bulk of cleaning required has to be done by manual labor with the boiler out of service. In addition to the standard type sootblowers, the Reed Station boilers are equipped with "telescopic sootblowers" which are designed to operate on the boiler tubes adjacent to the furnace in the high temperature region which would destroy the conventional sootblower. These telescopic sootblowers retract from the boiler when not in actual operation and are effective in removing a considerable portion of the slag which accumulates on the rows of boiler tubes close to the furnace.

The external cleaning necessary with manual labor when the boiler is out of service consists of breaking the heavy hard slag deposits from tubes and furnace walls by prying and pounding with blunt chisel pointed bars. Dust deposits are blown from the tube banks with compressed air hand lances and scale or soft slag is scraped off with hand scraping tools. Men engaged in these cleaning processes wear goggles and respirators or dust hoods to protect eyes and breathing organs from the dust. The job is also generally hot due to the boiler retaining heat long after it has been taken out of service. After a boiler is taken out of service a period of 8 to 12 hrs is required to cool it sufficiently to permit men to enter the manholes which provide access to the tube banks requiring cleaning.

The frequency of boiler outages for external cleaning is determined mainly by the output at which the boiler operates, the higher the output and

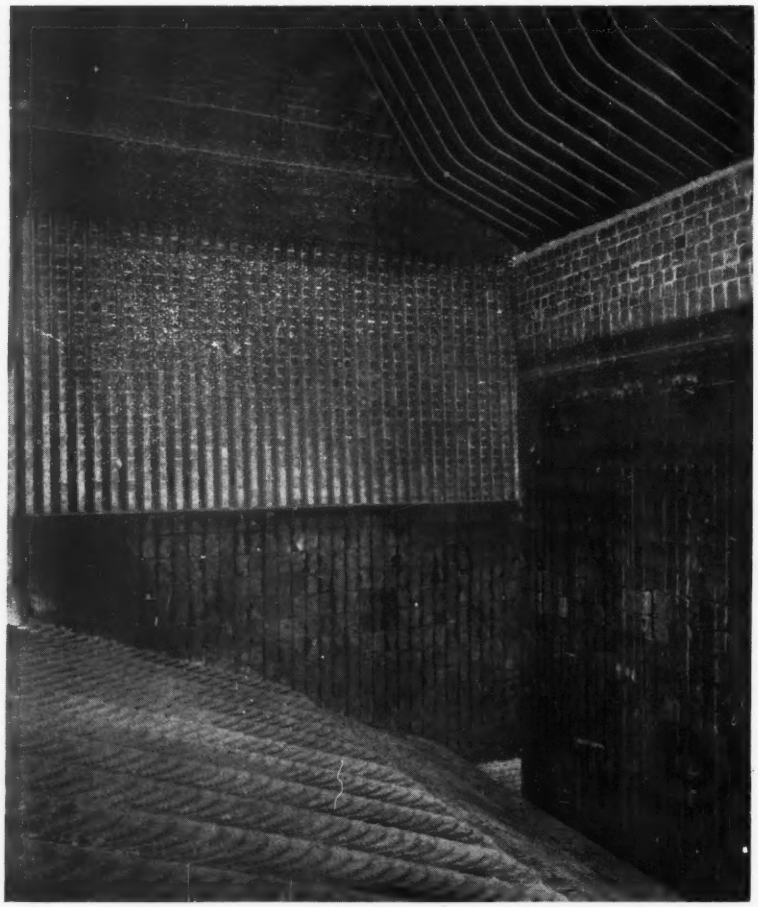


Fig. 3. James H. Reed No. 1 Unit Boiler Furnace before being placed in service

the greater the duration of high output, the more frequent the need for cleaning. The load demand on the Reed Station boilers is such that each of these boilers must be taken out of service for two days for cleaning at about six week intervals. On the Brunot Island boilers operating conditions are not so severe and outages at about three month intervals for cleaning meets the requirements. However, if the demand on the Brunot Island boilers were comparatively as heavy as on the Reed boilers, it would be necessary to schedule cleaning outages at about four week intervals.

Internal boiler inspection and such internal cleaning as may be necessary is done on schedule once each year at which time official inspection is made for insurance and for issuance of State Boiler Certificate. In addition other internal inspections may be made during the year if leaking tubes are renewed or repaired or other conditions develop which require draining the water from the boiler.

In general, boiler outages are scheduled according to the need for external cleaning, however off-schedule outages are necessary at times due to such developments as tube leaks, breakdown, or distress of auxiliary equipment. At such times cleaning is usually also done while other repairs are being made.

Tube Leakage

Leaks develop from time to time on the boilers. If the leak is slight and in an inaccessible location it may not be detected while the boiler is in service. Such slight leaks are located by placing a hydrostatic pressure test on the boiler when it is out of service. Hydrostatic tests are also always applied after leaks are repaired before a boiler is returned to service.

Leaks which become evident while the boiler is in service sometimes require immediate outage of the boiler; at other times the outage for repairs to the leak can be postponed for a while to a more convenient, depending on the location and severity of the leakage.

Repairs to leaks on the boiler proper usually involve tube renewal, rerolling of the tube ends where they are expanded into drums or headers, or repairs to gasketed joints on hand hole caps on the tube headers.

Leaking tubes which have to be renewed are generally found to have developed leakage due to internal corrosion of the tube by oxygen entrainment or acidic elements in the boiler water. External corrosion may also cause tube leaks. External corrosion results from acid formed by the combining of moisture and the sulphurous products of combustion in the flue gases. External corrosion most commonly occurs in the cooler passages where temperatures are low enough to permit condensation from the flue gases, as in the economizers. Tube leaks also may result from external cutting of the tube by close range impingement of misaligned sootblower jet or impingement from an adjacent leaking tube. On the Reed boilers, there have been no tube leaks resulting from internal corrosion, this type of leak being confined to the Brunot Island Station boilers exclusively. This is explained by a comparison of the feedwater systems in the two stations. In Brunot Island, make-up water is supplied by a water softener and feedwater is heated in open feedwater heaters. In Reed the make-up water is supplied by evaporators; feedwater is heated in closed heaters; equipment is provided to remove oxygen and other entrained gases from the feedwater; and the system is equipped to exclude and prevent infiltration of air into the water.

Repairs to leaks on piping connected to boilers and auxiliaries may involve renewal of fittings or sections of pipe, welding of leaks, and repairs to gasketed joints. In making repairs to piping much use is made of welding, both by acetylene and by electric arc. By utilizing the advantages of welding, time can be saved on the job, piping layouts can be simplified, and the number of joints and fittings which are potential points of leakages can be reduced. Welding equipment and oxy-acetylene cutting equipment is also extensively used on practically all other boiler room repair work, in fact it use has developed to the stage where it is considered practically indispensible for boiler plant maintenance work.

Stokers

Stoker repair is another major item requiring a frequent regular routine, in fact the need for stoker repairs is about equal to the need for external cleaning of the boilers as a factor in determining the need for boiler outages. Stoker parts which are in the furnace are subjected not only to wear but also to the intense heat of the fire and therefore deteriorate rapidly. All such parts are made of cast iron which is resistant to burning.

The rate of deterioration of those stoker parts exposed in the furnace is generally proportional to the rate and total quantity of coal burned per unit of stoker area. It is also influenced to a pronounced degree by the temperature of air supplied to the stoker, the severity of service being much harder on those stokers operating with air preheaters than on those without. Another factor is the skill exercised by the operator in controlling the fuel

bed on the stoker and the air flow through the fuel bed. Lack of skill in this respect causes burning of castings in concentrated areas, the stokers operating with preheated air being more susceptible to damage from this cause than those operating with cold air.

Stokers are designed for ease of removal and replacement of those parts requiring frequent renewal and generally a considerable number of parts can be replaced easily. However, should severe burning occur in concentrated areas, the castings may fuse into a solid mass and require the application of cutting torches, chisel bars and sledge hammers, crow bars, and lots of heavy labor to remove the mass and prepare for installation of new parts.

Three of the six Reed boiler units are equipped with air preheaters. On a scheduled six week interval outage of one or the units equipped with an air preheater, a typical tabulation of stoker castings renewed will show 350 to 450 parts representing a total weight of three to four tons of castings. A similar tabulation for one of the Reed Station boilers not equipped with an air preheater will show about 100 to 150 parts renewed, representing about one ton of weight.

Pulverizers

Pulverizer mills on the pulverized coal fired boilers in Brunot Island Station require periodic renewal of parts which wear rapidly due to the duty imposed on them of reducing coal to fine powder. These mills are of the direct fired unit type. Rotating hammers of manganese steel batter the coal against manganese steel wearing plates in the pulverizing chamber and an exhauster fan draws the pulverized coal from the pulverizing chamber and blows it through transport piping to the furnace burners. Routine maintenance on these pulverizer mills consists of inspection at two week intervals at which time hammers, wearing plates, and exhauster fan blades are renewed as found necessary.

Air Preheaters

The air preheaters, which are auxiliaries to three of the Reed boilers, require cleaning on the same schedule as the boiler proper. These are tubular type air preheaters consisting of 2½ in. diameter tubes set vertically. Hot flue gases from the boiler pass through the economizer and then pass through the air preheater tubes. Air from the forced-shaft fans passes over the outside of the air preheater tubes and is thus heated on its way to the stoker. Dust and condensed vapor products of combustion in the gases adhere to, coat, and plug the insides of the tubes. These deposits must be removed to keep the air preheater operating efficiently. Cleaning is done with the boiler out of service. Cleaning tools used include compressed air-operated turbine tube cleaners, ram rods, and augers. Cleaning is also done by washing with water hoses.

Deposits in the air preheater tubes are highly corrosive due to the sulphurous products of combustion condensing from the gases at the temperatures at which the air preheaters operate. These corrosive deposits cause the steel tubes to deteriorate rapidly. Retubing of the air preheaters has been necessary at about three year intervals. This is a repair job of major proportions involving a lot of hard work and careful planning in order to complete the job as quickly as possible to avoid the loss of service of a large boiler unit any longer than necessary. A typical air preheater retubing job could be represented by that of Reed No. 4 boiler on which 2160 air preheater tubes, each 2½ in. in diameter and 20 ft. long, were renewed. A crew of 40 men divided in two shifts, each shift working 10 to 12 hr per day, did the job in ten days.

Fans

The induced draft fans, which draw the hot gases from the furnace through the boiler unit and then discharge them to the smoke stack are subject to wear from the abrasive action of dust particles which are carried from the fuel bed by the gases. The rate of wear on the fans is determined by two main factors; first the quantity of dust, which is proportional to the rate at which fuel is being burned; and secondly by the speed at which the fan operates. The rate of wear mounts rapidly as fan speeds are increased. Load conditions on the Reed Station require high speed operation of the variable speed induced draft fans for the greater part of the time which results in fairly heavy fan wear. The rate of wear is such that a 12-week interval inspection schedule has been established on each fan. Repairs are made to worn fan blades by welding wearing strips to them over the areas subjected to concentrated war. This results in greatly prolonging the life of the fan blades before eventual renewal is necessary. Following each repair job it is necessary to dynamically rebalance the fan rotor. It also often becomes necessary to rebalance induced-draft fan rotors due to uneven accumulations of scaly dirt deposits and uneven wear. On such occasions the rotor is first cleaned, then rebalanced. Forced-draft fans handling clean air only seldom become unbalanced and are not subject to blade wear as are the induced draft fans.

Ash Handling

Ash handling equipment is subject to heavy wear due to the abrasive nature of the ash and clinkers handled. In Reed Station each stoker has a clinker grinder at the bottom of the ash pit which breaks the clinkers into a size convenient to handle and discharges the refuse from the ashpit to a water-filled ash hopper at the same rate as the stoker discharges to the ashpit.

The refuse is periodically removed from the ash hoppers by sluicing systems. The sluicing system for three of the boilers includes a concrete sluice trench lined with heavy semi-circular cast iron plates. High pressure water nozzles are spaced at intervals along the bottom of the trench, the water streams propelling the ashes along the trench to an outside ash disposal basin from which trucks are loaded with a clam shell crane bucket for haulage to the ash dumps. High pressure water nozzles are also provided to wash the ashes from the ash hoppers into the trench. The cast iron liner plates in the sluice trench are subject to heavy wear due to the abrasive ash sliding over them in the high velocity stream of water from the trench nozzles. Approximately 100 to 150 tons of ash per day are handled from the three boilers served by this sluice system. It is necessary to schedule repair work so as not to interfere with the intermittant operation of the sluice system, therefore renewals of trench liner plates are made several plates at a time during the intervals between operation of the system.

The other three boilers in Reed Station are served by an ash sluice system of different design. This system uses a 12-in. cast iron pipe instead of a sluice trench. In the operation of this system the contents of the ash hopper are first agitated into a soupy mixture by high pressure water nozzles in the hopper. The hopper gate is then opened and a large "Eductor" nozzle below the gate propels the mixture of ash and water through the 12-in. cast iron conductor pipe to the outside disposal basin. Routine repairs to this system consist of periodic renewal of wearing plates in the ash hoppers and renewal of sections of the cast iron conductor pipe. The conductor pipe is subject to heaviest wear at bends where direction of flow is changed.

In the Brunot Island Station, ashes are dumped from the individual boiler ash pits into electric motor driven cars. On the Murphy and Westinghouse stoker-fired boilers the cars haul the ashes directly to the dump. On the pulverized coal and chain grate stoker-fired boilers the cars dump into a hopper from which the ashes are sluiced by a sluice trench system similar to that in Reed Station.

In the Reed Station, siftings collected in the stoker windbox hoppers, and soot and fly ash collected in hoppers on the boilers and induced-draft fans are removed by a conductor piping system in which a conducting air stream is induced by an ejector which is operated by high pressure water nozzles. The abrasive nature of the materials handled by this system

causes rapid wear so that the maintenance resolves into a continuous routine of renewal of sections of conductor pipe and fittings. Wear is heaviest at fittings where a change in direction occurs.

Sootblowers

Sootblowers require constant attention from a maintenance standpoint. The conventional type of sootblower, when located in gas passages near the furnace, is subjected to heavy punishment due to high temperature which causes burning, warping, and elongation of the blower. Sootblowers used in these locations are made of heat resisting alloys, nevertheless, frequent repairs or renewals are necessary. Sootblower locations in or near the exit gas passages do not impose such severe service due to lower temperatures and considerably less repair work is required in these locations. In the coolest locations, sootblowers made of plain steel stand up quite well. Alignment of sootblower jets must be closely watched to keep the jets blowing down the lanes between tube rows instead of impinging directly against the tubes at short range. Direct impingement of a sootblower jet against a boiler tube will cut a hole in the tube and cause it to leak. The steam admission valves in the sootblower heads must be kept leak proof, otherwise furnace gases will leak back through the leaky valves when the sootblowers are not in operation and will cause rapid deterioration of the sootblower steam piping due to acid corrosion.

The telescpic type sootblowers which are on the Reed Station boilers in addition to the standard blowers, are designed to retract from the boiler when not in operation. These blowers are located at the front of the front tube bank in a region where a standard type blower could not withstand the high temperature. From a maintenance standpoint, the telescopic blowers escape much heat punishment and the attendant deterioration but the driving motor, gearing, bearings, packing, etc., are items requiring maintenance attention.

General Maintenance

Besides the regular routine of boiler cleaning and renewal of parts subject to rapid deterioration such as has been described, a procedure of periodical dismantling of equipment for inspection and overhauling must be carried out by the boiler maintenance crew. It is necessary that the condition and life expectancy of parts be determined so that renewals or repairs can be scheduled and made before actual breakdown occurs. However, breakdowns do occasionally happen regardless of preventive measures which may have been taken and on such occasions quick repairs may be necessary if the breakdown cripples major equipment.

Parts can frequently be satisfactorily repaired rather than renewing them. Also many repair items are fabricated in the station ships. In many cases, the life of parts subject to heavy wear is prolonged to a considerable degree by patching or building up of worn areas. Welding equipment is extensively used for this purpose.

A 500-KV Power Transmission Test Line Planned

That most necessary commodity, electric power, never had to be rationed in this country during World War II. The same forward thinking, the same careful planning that enabled the electric power industry to take both the civilian and war demands in stride are again in evidence. Looking to the immediate future, when even larger blocks of power will be needed to produce goods for the rehabilitation of much of the world, Mr. Philip Sporn, Executive Vice President and Chief Engineer, American Gas and Electric Service Corp., has initiated an investigation of the problems attendant upon transmitting power at voltages as high as 500,000 volts.

In cooperation with nine manufacturers, namely:

Westinghouse Electric Corp.
General Electric Co.
American Bridge Co.
Aluminum Company of America
Anaconda Wire and Cable Co.
General Cable Corp.
Phelps Dodge Copper Products Corp.
Ohio Brass Co.
Locke Insulator Corp.

the American Gas and Electric Service Corp., plans to erect for test purposes two 3-phase power lines adjacent to the Tidd Generating Station of The Ohio Power Co., at Brilliant, Ohio. Participating in this work will be not only The Ohio Power Co., but the other two principal companies of the Central System, namely, Appalachian Electric Power Co. and Indiana & Michigan Electric Co. These mile-and-a-half power lines will be so built and equipped that thorough studies can be made of some of the important factors that control the economic application of transmission voltages higher than 287 kilovolts, the present maximum voltage used.

Investigations will be centered about corona loss, radio interference, and insulation coordination at high voltages. Tests will be made at voltages from 264 to 500 kilovolts. These investigations are expected to provide essential data for the design of transmission lines and terminal equipment for the economical transmission of power at these high voltages in the relatively near future.

Present plans call for materials and equipment for these investigations to be supplied as follows:

Westinghouse will provide the high-voltage transformers with lightning arresters and the metering equipment to energize the line. Metering equipment of high sensitivity and accuracy will be provided for measuring corona loss and other test phenomena not only for selected conditions, but also for weather conditions as encountered throughout the year.

The transmission line towers to be supplied by the American Bridge Co., will be designed so that various conductor spacings can be used. These towers will permit close simulation of actual service conditions by having three prase conductors and two ground wires.

Transmission line conductors of various types and sizes will be supplied by the Aluminum Co., Anaconda Wire and Cable Co., General Cable Corp., and Phelps Dodge Copper Products Corp. Tests on the conductors will be made under varying conditions of weather, spacing, and insulator string length.

Switching equipment designed for a higher voltage than any heretofore built with lightning arresters, current transformers and potential devices will be supplied by the General Electric Co., in order to obtain experience on these important elements of station equipment.

Insulators and hardware will be provided by the Ohio Brass Co., and the Locke Insulator Corp.

Construction of transmission lines for voltage in excess of the present maximum operating value (287 kilovolts) is technically feasible at this time, based on experience with lower voltage design. However, lower cost construction is expected to result from the date which will be obtained with the proposed installation, as the extended knowledge should permit more closely evaluating the margins now believed necessary in the selection of conductor diameter, spacing, insulation levels of line, and terminal apparatus. The purpose of American Gas and Electric Service Corp., in undertaking this investigation is to provide authentic data and information to permit balancing the factors that influence high-voltage transmission and to find the basis for the most economical design for transmission of large blocks of power.

Algae Control in Water Supplies

Losses caused by growths in water supply to power plants are due to interference with heat transfer, stoppage of passages, time out for cleaning . . . Requirements of algaecide listed . . . Research conducted to develop algaecide . . . Performance of algaecide mixture in spray pond . . . Condenser performance with algaecide treated water

By MAX GELFAND Chemist, Dallas Power & Light Co.

GROWTHS of algae, moss, fungi, slime, etc., in water have produced various hazards in cooling water, such as found in spray ponds and cooling towers. This vegetable growth, which accumulates in condenser tubes and basins, decreases the flow of water and reduces heat transfer to such an extent that periodic mechanical cleaning becomes necessary for continuous operation. The inefficiencies and lost operation, due to this type of deposit, have been and will continue to be serious and costly.

Careful consideration of the entire problem of algae control has led to the listing of the following as the necessary qualifications of a good algaecide:

1. Effectiveness in any condition.
2. Availability for continuous use.
3. Economical.
4. Ease in storing and handling.
5. Simplicity and economy in its use.
6. Simplicity in the determination of its presence, both qualitatively and quantitatively in very small amounts so that its concentration may be accurately and easily controlled.
7. Non-injurious to any other living matter except for the purpose for which it is to be used.
8. Harmless to equipment in which it is present.

Study of Algae Made

Because no such algaecide could be obtained, a careful and lengthy study of various of the most abundant algae was made in search for such a substance.

A great number of chemicals were tried in the attempt to render these plants immune to growth and aid in their destruction, and the conclusion after ten years of intermittent work, resulted in a mixture of chemicals that had all of the qualifications of a good algaecide. In fact, not only did this chemical mixture retard the growth and kill this algae, but produced a chemical immunity against active corrosion due to sulfide gases.

Such gases derived from the thio bacteria (a major problem of the Southwest) are extremely corrosive to metals, protective coatings and paints that are used in the protection of these metals.

It was found, both in the laboratory and actual field tests, over long periods of time, that this algaecide mixture not only retarded growth, but killed some of the most hardy algae in as little as three days at concentrations from 1.7 to 5 parts per million as Cu; and, that as long as the necessary concentration was held, the water was immune to further aglae growth.

From studies of the subject and the proven effectiveness of copper salts, it was decided that if the toxic copper ions could be kept in solution regardless of the pH value and operating temperature of the water a good algaecide might be obtained.

An alkaline solution of copper sulphate prepared in the form of Fehlings solution and the alkaline copper sulphate in glycerin potassium hydroxide (reagent for silk), both having high pH values proved definitely that water soluble copper salts could be kept from precipitating out in alkaline waters. Further study revealed that any aliphatic hydroxy acid or its water soluble salts would render copper ions soluble in alkaline waters if the proper quantities of these organic chemicals

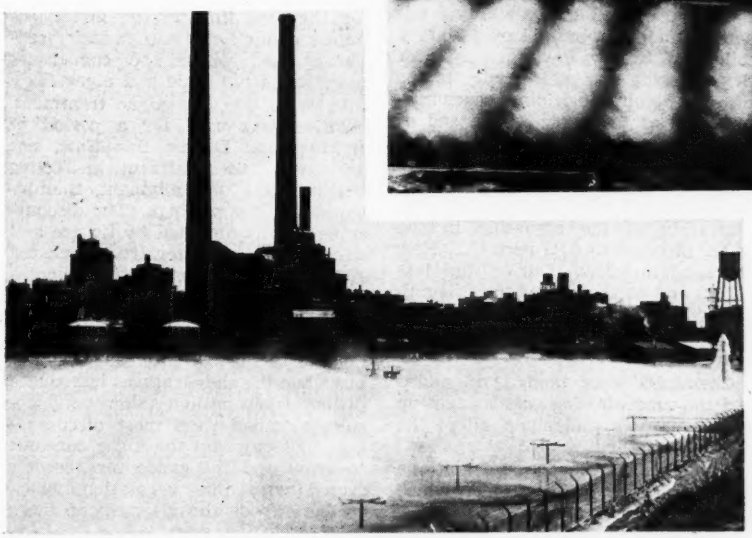


Fig. 1. (Left) View of Dallas Power & Light Co. plant with spray pond in foreground

Fig. 2. (Above) View of 11 million gallon spray pond serving Dallas Power & Light Co. plant

Fig. 3. Spray arms showing algae growth before treatment with new algaecide mixture

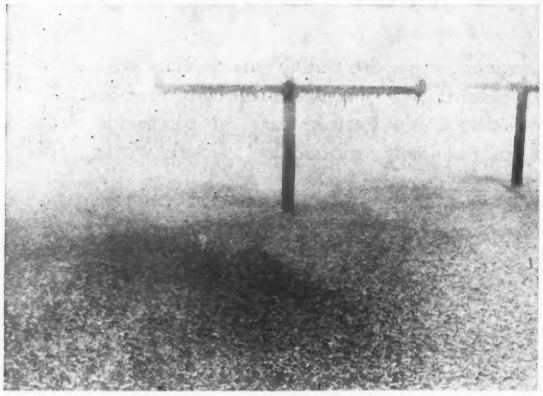
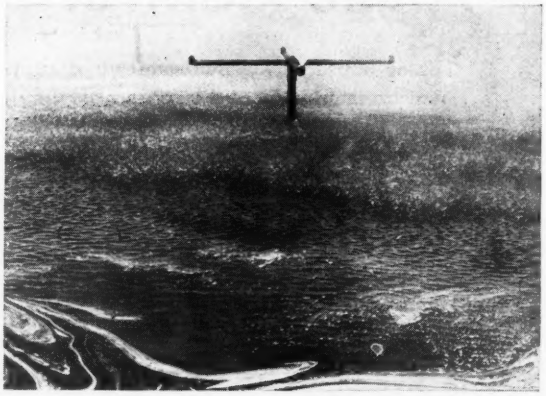


Fig. 4. Spray arms showing the effects of the new algaecide three days after treatment



were properly mixed with the copper compound and placed into solution before entering the water to be treated.

The curve, Fig. 8, shows the quantities of some of these aliphatic hydroxy acids that were found necessary to keep copper sulphate from precipitating out in alkaline waters. Adversely to the general chemical reaction, an increase in molecular weight results in less of the organic acid needed per pound of copper sulphate.

When the water soluble salts of these acids are used, the quantities necessary are proportioned to equivalents of the corresponding acids.

Fig. 5. Typical blue-green scum (floating algae) composed of Oscillatoria, Rivularia, Nostoc and Zygospores. Other algae types that were present in the water are Aphanothece, Pleurococcus, Diatoma and Navicula

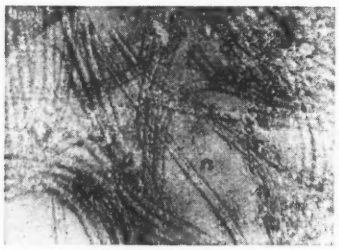


Fig. 6. Oscellatoria—Microphotograph

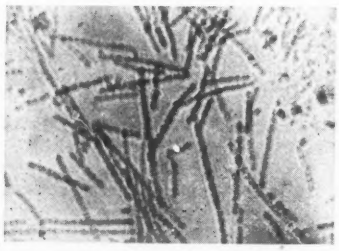


Fig. 7. Navicula—Microphotograph

Algae Growth Stopped in Spray Pond

In the Dallas Power & Light Co.'s spray pond, 11,000,000 gal of water, this algaeside mixture successfully controlled the growth of vegetation, for the first time since the pond was placed in operation (1923).

Treatment was started on April 29, 1944. Four thousand fifty pounds of the chemical mixture was added to the pond water, which produced a residual of 6.75 ppm of the Cu ions that were toxic to the algae. At this time, the water contained large quantities of floating algae and all the spray arms were covered and hanging with the vegetable growth. At the end of the third day after the incorporation of the algaecide, most of the algae in the pond died and large pieces from the spray arms broke loose. A little over a million gallons of water (about one-tenth of the original quantity) was removed by draining, removing large quantities of the dead and floating algae.

Inspection of the concrete sides of the pond showed that all of the adhering vegetation broke loose. For the following twenty days, make-up of the algaecide was added daily to the water to retain the original concentration. All of the algae at the end of this period was removed from the pond water.

During the next twenty-two days, no chemicals were added and the concentration of the algaecide in the water dropped to 0.85 ppm Cu. New algae again grew. During the test period and at the end of the fifteenth day, when the concentration dropped to 1.7 ppm Cu, it was noted that the algae began to reappear.

Chemicals were then again added and the concentration was brought up to 2.7 ppm Cu and again all of the algae was killed.

Inspection of a condenser of one of the 30,000 kw units, through which the spray pond water flowed, showed that all the tubes were clean and no algae deposit whatsoever was present. And that condensers of this machine and of two large units were operating at an efficiency better than factory guarantee.

At this time, it was necessary to substitute amonium chloride for citric acid in the algaecide mixture due to insufficient supplies; and thus, with this substitute during the following thirty-three days, the algaecide was added to the pond water. Inspection of another of the large condensers showed that, although no algae was present, a discoloration due to the precipitated copper hydroxide was on the tube sheets and in the tubes. This green deposit was fixed and could not be removed by wiping.

The replenishment of the citric acid enabled the discontinuance of the amonium chloride and the summer season was finished with the original chemical mixture.

Throughout the 1944 and 1945 season, it was definitely proven that the algae could be destroyed under any existing conditions within at least three days. That the loss of chemicals averaged about 0.31 ppm Cu per day at 20 per cent makeup or 15.5 lb Cu per million gallons, and that, for the first time in the history of the company, two entire summer seasons passed where the condensers were free from scale and algae.

Prior to this new algae treatment, chlorine was used for a period of eight years. During this time, not only was this treatment ineffective but the cost of equipment, maintenance and gas ran high. The discouraging results obtained by its use and effect led to an extensive search for a better algaecide. Sodium pentachlorphenate was thus tested and tried. As previously mentioned, laboratory tests and a number of small field tests showed promising results, but when the chemical was introduced in the eleven million gallon pond, results obtained were most discouraging. Not only did the algae continue to grow and the condensers become coated with this vegetation which brought about the cleaning of these

condensers and loss in heat transfer, but there never was any control, either on the quantity or presence of the algaecide in the water. Therefore, the research program for the discovery of an effective algaecide.

Condenser Performance

In the month of February, 1944, the condensers on three of the 25,000 kw units at the Dallas Power & Light Co., Dallas Steam Electric Station, had been completely cleaned and all of the calcium carbonate scale removed. The condensers on two smaller units, which contained a considerable quantity of similar scale deposit, were not cleaned.

During the February, 1945, overhaul, inspection showed that the condensers which were previously cleaned were not affected either by scale or algae and carbonate scale in the condensers of the smaller units had practically disappeared.

To date, these condensers and equipment through which the highly alkaline spray pond water flows are free of algae and scale deposits and have been so since the use of the new algaecide mixture.

The use of sodium citrate as a preventative against the precipitation of calcium has been known for a long time and the presence of this chemical within the water, even in the small quantities as used has shown beneficial results.

During a study of water parasites, mosquitoes, etc., it was found that the concentrations of copper as recommended were extremely detrimental to these organisms.

In accordance with public health standards, a maximum of 3 ppm as Cu ions are allowable in rivers, lakes, etc., and this concentration is within the range for algae control.

The qualifications of the new algaecide and illustrations for its effectiveness are as follows:

Effectiveness

This chemical mixture is so designed as to work effectively to destroy or retard growth of the most hardy algae in any type of water. Its effectiveness is not altered, either in highly acid or highly alkaline waters, and may be used throughout the entire pH range.

Concentrations from 2.5 to 5 ppm Cu are recommended.

It is a water soluble, non-volatile solid and is thus easily placed into solution and, once placed in the water, will equally distribute itself through the entire volume. The major loss of the toxic constituents are due to overflow and driftage.

Chemically, it reacts with the algae and, consequently, where large quantities of this vegetation is present, more of this algaecide will be consumed. As the algae growth is reduced, less chemicals will be used until there becomes an equilibrium between the rate of growth of new algae and chemicals consumed in the destruction of the plants. This, then, is the minimum lethal concentration. Ordinarily, the make-up will depend upon the quantity of fresh water added to the system daily, plus that consumed by the algae.

Availability

The constituents of the algaecide are well known chemicals which, normally, are readily obtainable in the chemical market in any quantity and, therefore, insures a constant supply so that continuous treatment and control may be had without any interruption. Once the algae is under control, the problem is only that of maintaining the necessary concentration of chemicals that are needed for the proper toxicity.

Cost

Since the chemical constituents of the algaecide are normally abundant and only commercial grades need be used, the corresponding price, therefore, is small and the use of the algaecide is very economical.

Ease in Storing and Handling

The algaecide is produced in a form that is most convenient in storing and handling and may be packaged in any type of container, bags or wooden barrels.

No special care need be had for its storage except that the location is kept dry and free from the weather.

No extra precautions are necessary for handling inasmuch as the chemicals are inert in the dry forms.

Simplicity and Economy in Its Use

No elaborate and expensive equipment is necessary for the introduction of the chemicals in the water.

It is suggested that the algaecide first be placed into solution before adding to the main body of water. Any improvised method for doing this is satisfactory, and it is suggested that an ordinary wooden barrel, into which the chemicals are placed and allowed to go into solution by means of adding a small stream of water into the barrel, allowed to overflow into the water to be treated, is very satisfactory. There is no reaction between the wooden barrel and the chemicals and consequently the maintenance of the procedure is nil. Of course, the chemicals may be directly dumped into the water; or, if obtained in cloth bags, may be suspended so the natural flow of the water may place the chemicals in solution.

However, as these chemicals are a physical mixture in the necessary proportions so that when previously dissolved will produce an exact homogeneous solution throughout, best results are then obtained when previously dissolved.

Simplicity in Control

No elaborate equipment or special technique is necessary for making an accurate determination of the quantity of the algaecide concentration in the water.

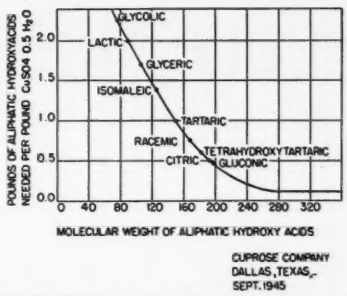


Fig. 8. Amounts of aliphatic hydroxy acids necessary to render copper hydroxide soluble in alkaline waters

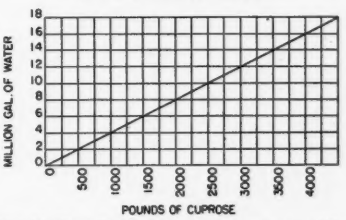


Fig. 9. Quantity of algaecide mixture (Cuprose) to be added vs gallons water to produce four parts per million Cu (20 ppm $CuSO_4 \cdot 5\ H_2O$) based on 2 $CuSO_4 \cdot 5\ H_2O$ plus 1 $C_6H_8O_7 \cdot H_2O$

Directions for adding Cuprose. Example: Capacity of pond—10 million gal; Make-up per day—1 million gal; Initial dose—2500 lb; Make-up per day—250 lb.

The method employed is colorimetric. Only two reagents (amonium hydroxide and sodium diethyldithio carbamate) are used and the color developed in an accurately measured sample of filtered water compared to standard colors of known concentrations of the algaecide give accurate results. As little as ¼ ppm Cu may be easily and accurately determined in just a few minutes time.

Toxic Effects

As previously explained, the chemicals are non-injurious in dry form. In solution, the concentrations used are only harmful to lower forms of life and, if the water be used for human consumption, will produce no ill effects.

Effects on Equipment

Except in heavy concentrations, such as in the dissolving vat, is this algaecide corrosive to metals; and, therefore, as suggested, wooden containers should be used.

In the quantities that are present in water (2.5—5 ppm as Cu) no corrosive reaction is encountered.

Where waters are acid and are actually corrosive on their own accord, no change will be effected by the algaecide. Where waters are corrosive, due to various organics and hydrogen sulfide gas, the algaecide will definitely react with these constituents to retard this corrosion. Of course, such constituents reacting with the algaecide will bring about the use of a higher make-up of the chemical mixture in that two jobs are being accomplished, namely, corrosion as well as algae control.

FLUORESCENT LAMPS AND LIGHTING

This is the second of two articles dealing with the practical aspects of fluorescent lamps and lighting systems. Last month, the author discussed briefly the characteristics of fluorescent lamps as compared with those of other types of lamps. Now, in this article he first describes the circuits used with fluorescent lamps, the types of ballasts and starting devices used and finally presents a consideration of installation and maintenance factors involved in fluorescent lighting

By A. K. Gaetjens

Lamp Department, General Electric Co. Nela Park, Cleveland, Ohio

FLUORESCENT LAMPS in common with all electric discharge light sources require some current limiting device in the circuit. Such lamps have a negative volt-ampere characteristic; that is, the greater the current, the less the voltage drop in the lamp. Thus, on an unlimited power supply the lamps are instantly destroyed.

On d-c circuits the current limiting device must be a resistance in series with the lamps, although a reactance also is commonly employed to obtain a high voltage transient to aid in starting. In operation, resistance in the circuit is the only means of limiting direct current. Usually, the wattage loss in the resistance is approximately equal to the lamp watts, and for this reason fluorescent installations on direct current are less efficient than those on alternating current.

The following discussion of a-c circuits is based in large measure on a recent paper presented before the last Technical Conference of the Illuminnating Engineering Society.[1] Alternating current circuits contain impedances in the form of resistance, inductance, capacitance or a combination of the three. The wave form of both current and voltage in a circuit containing F lamps is complex. For this reason the usual alternating current formulae cannot be used in calculating ballast design since they are based upon a sinusoidal wave form. Ballast characteristics are determined most satisfactorily by experimental and empirical methods.

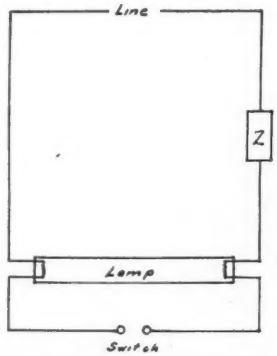


Fig. 3.* Fundamental circuit for starting and operating preheated fluorescent lamps

Figure 3 indicates the fundamental lamp circuit. It consists of a suitable voltage supply, a ballasting device in series with the lamp and a starting switch or starter in parallel with the lamp. Types of starters are discussed in detail in a separate section. Their function is to short circuit the lamp during the starting cycle and connect the two cathodes in series through the impedance to permit a cathode preheating current to flow. After a suitable time interval, the switch opens and a high voltage transient due to the inductance in the circuit appears across the lamp, establishing the arc. The lamp voltage in operation is approximately half the open circuit secondary voltage of the ballast on the majority of circuits.

Figures 4, 5, 6, 7, 8, 9 and 10 show various means of ballasting a 40 watt F lamp. The caption also indicates the effect of the different impedances upon the lamp voltage and wattage when the circuit voltage and the lamp current are held constant. In Fig. 4 the resistor may be either the wire wound resistance or a properly designed filament lamp. The oscillogram of voltage and current shows that the current does not begin to flow until the voltage has reached a high enough value to sustain the arc in the lamp. It should be noted that the current flows for only a portion of the half cycle and therefore the lamp wattage is somewhat less than its design value. The light output also is reduced in nearly the same proportion as the reduction in lamp watts. As mentioned above in the discussion of d-c circuits, the wattage loss in the resistance is practically

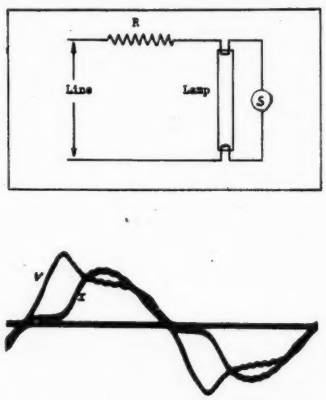


Fig. 4. Fluorescent lamp circuit with resistance control. Circuit voltage 200, lamp volts 111.5, lamp amperes 0.41 and lamp watts 35

equal to the wattage in the lamp and therefore a relatively low efficiency circuit is obtained with resistance ballasting.

In Fig. 5 the impedance is a suitable capacitor. It will be noted from the oscillogram that the current flows for only a very small portion of the cycle and therefore the wattage and light output are reduced to about half their design value. It would be possible to obtain design lamp watts by

* Figures 1 and 2 appeared in the first part of the article in the December issue.

[1] "Control Equipment for Discharge Type Lamps"—C. W. Kronmiller, General Electric Company, Apparatus Dept., Ft. Wayne, Ind.

increasing the lamp current. This, however, would be unsatisfactory since the lamp cathodes are designed for a given current value and increasing the current to such an extent would result in extremely short life. Also, with such a circuit the cyclic flicker of the lamps is more severe because of the very short proportion of the total time during which the lamp is emitting light.

In Fig. 7 the impedance is a reactor. This has proved to be the most satisfactory type of ballast since the current has nearly a perfect sine wave. The wattage loss in the reactor is also a minimum. The chief disadvantage of complete inductance ballasting is the resulting line power factor which is about 50 per cent lagging. This can be corrected by the use of external line capacitors. A

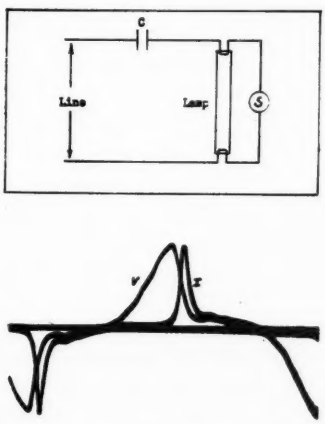


Fig. 5. Fluorescent lamp circuit with capacitance control. Circuit voltage 200, lamp volts 94, lamp amperes 0.408 and lamp watts 19

more suitable method of obtaining power factor correction is indicated below. Figure 7 shows a circuit controlled by combined inductance and capacitance in series. This can be designed to provide a leading line current to offset the lagging line current produced by an inductively ballasted lamp. By the proper selection of the values of capacitance and inductance the lamp wattage and wave forms are identical to those produced by inductively ballasted lamps. It has been experimentally determined that a ratio of the capacitor ohms to the reactor ohms of approximately 2.35 will provide the most suitable conditions.

Figures 8 and 9 show the result of increasing the ratio of capacitor ohms to reactor ohms. It will be noted that the current wave form becomes considerably more distorted and the lamp watts are reduced in such circuits. For this reason, the leading current circuit shown in Fig. 7 has been combined with the circuit shown in Fig. 6 in the so-called Tulamp ballast which provides essentially unity power factor with minimum ballast losses. In addition the two lamps are operated out of phase with each other, which reduces the cyclic flicker to a minimum when the two lamps are illuminating the same area. In most F lamp units, two or a multiple of two lamps are used in relatively close proximity, so that this reduction in cyclic flicker is easily accomplished.

One complication of the circuit shown in Fig. 7 is the necessity of providing adequate preheat current during the starting cycle. On the lag circuit (all inductance) the impedance during starting is only that caused by the reactor, and the resulting starting current is about 50 per cent greater than the normal operating current. On the lead circuit (reactor and capacitor combination) the net impedance present during normal lamp operation is approximately equal to the difference between the capacitance and inductance combination and the lamp's apparent inductance. During starting, however, with the lamp out of the circuit, the impedance is only that produced by the inductance and capacitance combination. As a result, the starting current is approximately equal to the normal operating current. This is not sufficient to give satisfactory cathode preheat, and a device known as a starting compensator must be used.

Figure 10 shows the circuit of a Tulamp ballast, one branch of which is controlled by an inductance (lag lamp circuit) and the other branch by an inductance and capacitance in series (lead lamp circuit). A starting compensator which today is contained in the ballast, is connected in series with the starting circuit of the lead lamp. During the starting cycle the starter switch inserts the compensator into the circuit. This reduces the net impedance of the circuit and the proper cathode preheat current is obtained. When the switch is opened and the lamp is in normal operation the effect of the compensator is eliminated. The high resistance shunt across the capacitor C-1 is used to bleed off any charge which might be present when the circuit is turned off. The capacitor C-2 in parallel with the starting compensator is used to suppress radio interference.

A ballast is essentially a single frequency device. Operation on frequencies other than its designed value will either greatly overload the lamp or cause it to operate at less than rated wattage. If a ballast is operated on a frequency greater than its design value, the lamp which it is operating will give reduced light output but no other harm will ensue. However, if a ballast is connected to a frequency less than that for which it is designed, the magnetic circuit will be overloaded and the lamp current increased to a value which might be injurious to both lamp and ballast.

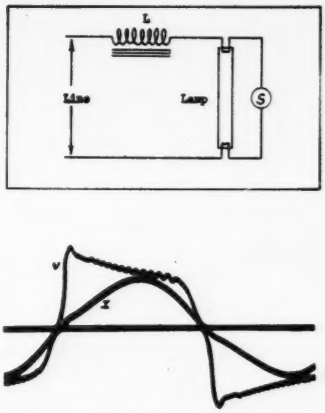


Fig. 6. Fluorescent lamp circuit with inductance control. Circuit voltage 200, lamp volts 108.5, lamp amperes 0.41 and lamp watts 40.2

This characteristic, plus the wide range of voltages encountered in service, requires an extensive line of ballasts. In addition to the standard ballasts for 50 and 60 cycle operation there are special ballasts available for operation on 25, 40, 143, 180, 400 and 800 cycles. The most common voltages are 118, 208, 236 and 260. For many of the lamps, high and low power factor units are available as well as single and two lamp units.

As mentioned before, it is possible to start a standard F lamp without the use of a preheating circuit and starter, by the application of a sufficiently high voltage. Figure 11 shows the circuit diagram of a Tulamp ballast with the lead and lag feature for operating lamps specially designed for instant starting. There are several differences from the standard ballast shown in Fig. 10. It will be noted that no starting compensator is needed. Also the radio suppression capacitors are in parallel with each lamp rather than in the starter as is customary with preheat circuits.

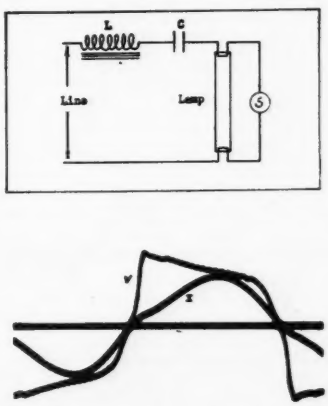


Fig. 7. Fluorescent lamp circuit with series capacitance and inductance control. Ratio capacitor ohms to reactor ohms 2.35. Circuit voltage 200, lamp volts 107, lamp amperes 0.41 and lamp watts 40

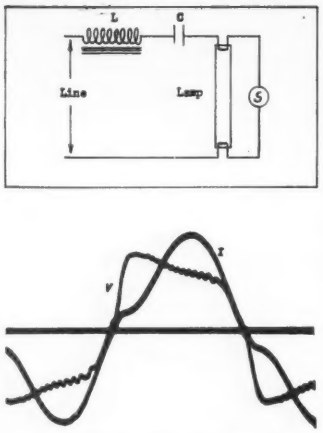


Fig. 8. Fluorescent lamp circuit with series capacitance and inductance control. Ratio capacitor ohms to reactor ohms 3.5. Circuit voltage 200, lamp volts 107, lamp amperes 0.41 and lamp watts 37

The open circuit starting voltage of this ballast is 450 volts, and for this reason it is desirable to interrupt the line circuit when a lamp is removed. Special lampholders have been designed so that when the lamp is inserted the primary circuit is closed. Removal of the lamp opens the primary circuit and eliminates the possibility of shock. These lampholders also short out the cathodes of the lamp. One recently announced development has been a lamp in which the pins are shorted internally so that no further dependence is placed on the shorting mechanism of the lampholder.

Starters

The starting switch or starter is an automatic device to provide the proper interval to preheat the cathodes. It

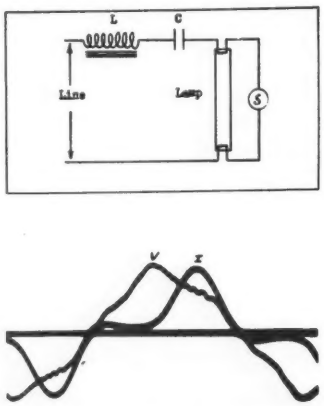


Fig. 9. Fluorescent lamp circuit with series capacitance and inductance control. Ratio capacitor ohms to reactor ohms 5.0. Circuit voltage 200, lamp volts 97, lamp amperes 0.41 and lamp watts 25

also provides a break in the circuit which due to the circuit inductance, insures positive starting by placing a high transient voltage across the lamps. All starters essentially depend upon a bimetal strip or strips with contacts at the free ends. Several methods of heating such strips are employed, but there are two essential subdivisions, namely voltage actuated and current actuated starters.

The most common type of voltage actuated starter is the so-called "glow" switch which is simply a very small electric discharge lamp which will glow on the open circuit secondary voltage of the ballast. It will not glow on the operating voltage of the lamp (about half the open circuit voltage). When the circuit is energized the glow of the gas heats the bimetal element causing it to deflect and close the contact, allowing the preheat current to flow through the cathode. When the contact is closed the glow discharge of the unit ceases and the unit cools. After the proper preheat interval has passed the contact opens, providing a high voltage inductance kick, and the lamp lights. The glow switch is so designed that it does not operate at the normal lamp voltage and is thus out of the circuit until the next start is made. The chief advantage of this type of starter is the fact that there is no wattage dissipation in the starter during normal operation. However, the inductive voltage available for starting a lamp is reduced somewhat because a portion of this energy is dissipated in the switch itself. For this reason it is not recommended for more difficult starting service such as direct current operation of the larger fluorescent lamps or for low temperature starting conditions.

With the current actuated starter the contacts are closed initially, permitting preheat current to flow through the cathodes as soon as the circuit is energized. A small heater coil is connected in series with the line. The preheat current flowing through this coil causes it to heat one bimetal strip. The strip then deflects, opening the preheating circuit and starting the lamp. While the lamp is lighted its current flows through the coil, developing enough heat to keep the starter contact open. As indicated above, this type of starter is more positive under difficult operating conditions than the glow type of starter.

One of the major developments in starter design has been the perfection of the so-called "No-blink" starter. With the types described above, the starter makes a continuous effort to start the lamp so long as the line is energized and the lamp is not operating. When a lamp reaches the end of life and the cathodes are deactivated the lamp will no longer sustain an arc. However, the original starters would continually attempt to start the lamp, producing an annoying flashing or blinking which would continue until the lamp was removed or the starter wore out. This was probably the most serious problem to overcome in the improvement of fluorescent lighting. Today, however, several types of starters have been developed which incorporate a small current actuated thermal circuit breaker. When the lamp starts to blink, it is using the higher preheat current almost steadily. The excess of current causes the circuit breaker to trip after a period of a minute or so. This opens the circuit and the lamp either starts once more from the inductive kick given by the opening of the circuit breaker or it goes out. In either event the blinking has ceased and when the circuit is turned on the next time no starting effort is made. With one type of starter this circuit breaker is reset manually at the time the lamp is replaced. In another completely automatic type a small holding coil keeps the circuit breaker open until the lamp is replaced and normal operation can be resumed. It is felt that such "No-blink" starters will do much

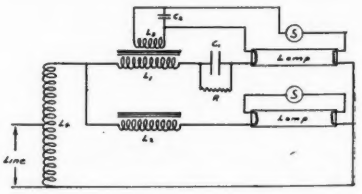


Fig. 10. Tulamp ballast circuit for operating two 40 watt tungsten cathode fluorescent lamps with preheat starting. Lamps operate out-of-phase to minimize stroboscopic effect and power factor is essentially unity

to overcome the operating difficulties which have faced fluorescent lighting.

However, with all starter circuits that have been developed to date there is a certain interval between the switching on of the circuit and the lighting of all the lamps. Since this is usually less than five seconds it is relatively unimportant. However, there seems to be a rather strong trend toward the use of instant start circuits on which the lamps light immediately when the circuit is energized. At the present time such circuits result in a more costly installation, from the standpoint of both initial and operating expense. Nevertheless, it is felt that instant starting circuits will become increasingly important.

Efficient Installations of Fluorescent Lamps

F lamps are inherently long light sources of relatively low brightness. Thus, glare from individual F lamps is much less than from individual tungsten filament or mercury lamps, both of which are relatively small, high brightness sources. However, it must be borne in mind that a great many more lamps are used and that

glare is due to more than the intrinsic brightness of the source alone. The degree of glare is also affected by the size of the light source and its angular height above the line of sight. For these reasons it is desirable to use reflecting equipment which controls the distribution of light from the lamp, redirecting it efficiently toward the work plane and minimizing direct glare or brightness toward the eye. With the older types of light sources (tungsten filament and mercury lamps) it was frequently desirable also to reduce the brightness of the light source as seen from the work area (reflected glare). This has not been found necessary for most industrial applications of F lamps. Consequently, conventional lighting equipment for factories and for many offices has evolved into a relatively simple reflector over the lamps which extends down on either side to shield the crosswise brightness of the lamp from view. With office equipment the endwise view also is frequently shielded, though to a lesser extent. In industrial applications there are relatively few places where endwise shielding has been found essential.

Some of the factors which must be considered in selecting equipment are:

1. Desired distribution of light and suitability for the particular interior being considered—which will depend upon the type of work conducted and the room proportions. For example, in a high, narrow room such as an industrial crane-way in which reflectors must be mounted above the crane, it usually is necessary to install fairly concentrating equipment. Suitable reflectors can be designed more efficiently for small, high brightness sources such as tungsten and mercury lamps than for F lamps. Thus, one finds such areas usually lighted with either of the first named sources or the two in combination.

For some high, *large* rooms such as airplane assembly areas, F lamps have been used effectively and efficiently where the type of work demanded a high quality of illumination.

2. Overall efficiency of the reflectors.

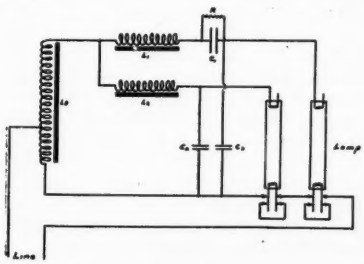


Fig. 11. Tulamp ballast circuit for operating two 40 watt tungsten cathode fluorescent lamps with instant starting. Starters are eliminated but ballast losses and initial cost are greater. Reduced stroboscopic effect and essentially unity power factor are obtained

Fig. 12. An excellent example of fluorescent lighting of a machine shop. Approved reflectors for two 40 watt lamps are laid out in a "grid" pattern to obtain optimum visibility with a minimum of shadows. Illumination in service approximately 80 footcandles

3. Ease of equipment maintenance. This includes the intrinsic rate of dust accumulation (which varies with the reflector design), the ease of cleaning and making lamp replacements.

4. Adaptability to the use of a larger lamp or more lamps if more light should be desired at a later date.

5. Mechanical construction feature;

6. Cost.

Maintenance

No discussion of lighting is complete without including consideration of its proper maintenance. F lamp installations are considerably more complicated from the standpoint of wiring and necessary accessories than the previously standard filament lighting. Also, there are usually more lamps in a given area. However, their advantages are so great that they have achieved wide acceptance despite the relatively greater maintenance problem. In many cases the fullest utilization of F lighting is not being obtained by the user simply through neglect of the lighting system. When the lighting is installed, provision should be made to reach it safely, economically and conveniently. A regular program of reflector cleaning should be instituted, the frequency of which will depend upon the rate of dirt collection. An analysis will show that it is economical in most cases to clean reflectors much more frequently than is common practice. Reflector cleaning in most installations should be not less than once every four months. In many cases, cleaning once a month will prove economical from the standpoint of the quantity of light received per dollar expended on the installation.

Also with F lamp installations it has been found that with the long life and large number of lamps involved, group replacement of all of the lamps at predetermined intervals is simpler and more economical than replacing the lamps one by one as they burn out. This system is now being used in many places. It is felt that the trend in this direction is amply justified by the greater quantity of light received for a given initial investment in equipment, and a fuller utilization of the dollars spent for power.

The Place of Fluorescent Lamps in Lighting Practice

Fluorescent lighting to date has been applied extensively to factories, particularly through the war period. Stores and offices are also using F lighting widely although to a lesser extent than would have been the case had the war not interfered with the the production of commercial lighting fixtures. Their use was confined to high priority locations because of material shortages. For the same reason, fluorescent in the home is still in its infancy although it is expected to be used widely in bathrooms, kitchens, garages, basements and other work areas in the home. The new circular fluorescent lamps will doubtless find wide application in portable lamps, and undoubtedly many types of fixtures for living rooms, dining rooms, etc., will become available in the postwar period.

What the Power Engineer Needs to Know About

THE PNEUMATIC CONVEYOR

What the pneumatic conveyor is . . . Handling ashes its principal power plant use . . . Details of two systems, one using exhauster, other using steam jet, to produce high-velocity air stream . . . Typical installations . . . Advantages and precautions in installing and operating . . . Single steam jet system . . . Multi-jet system . . . Can you handle coal satisfactorily with pneumatic conveyor?

By Wilbur G. Hudson

Consulting Engineer

THIS discussion of pneumatic conveyors will be restricted to their power plant usage, though there are other important applications, which they solve better than is possible with any mechanical conveyor or combination of conveyors. The pneumatic conveyor utilizes a high-velocity air stream, generated by a rotary exhauster or by the injector action of a steam jet.

Conveyor With Exhauster

The earliest general use of the pneumatic conveyor for handling boiler house ashes dates from about 1900. The routine layout is an 8-in. or 10-in. pipe extending along the ash-pit fronts with an intake "saddle" and plug at each. The duct then extends upward and across to a storage tank. When the air blast is maintained by a high-speed centrifugal exhauster or a slower-speed positive type exhauster, the tank is as nearly air-tight as possible and the exhauster maintains a reduction of pressure therein. A dust collector or air washer between tank and exhauster protects the latter from the abrasive effects of the dust. Since the ashes cannot be handled wet without plugging the elbows, a water spray is injected some distance ahead of the entrance of the duct into the tank. The ashes build up a high velocity, so a "target" off the end of the duct receives the impact. This target may be an open bottom cone, in which the ashes pack and thereafter spray downward.

With an air flow of 2500 cu ft of air per minute and suitable velocity, the handling capacity will be 300 to 400 lb of ash per minute, which is about the limit for one man. It is advantageous to offset the feed inlets as shown in Fig. 1, so the air blast is not completely blocked as each batch is shovelled in.

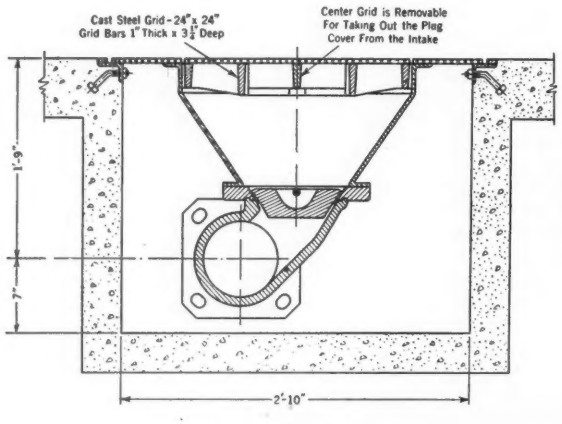


Fig. 1. Feed hopper and grid—offset type of ash conveyor.

Conveyor With Steam Jet

About 1905 the steam jet conveyor began to receive attention. It eliminated the costly motor-driven exhauster by maintaining the air blast with a steam jet nozzle, usually located at the up-turn. The steam also quenches hot ashes and to some extent serves to suppress the dust in the exhaust from the storage tank. The average cost of an exhauster-operated installation for a plant of 1500 or 2000 bhp was about $5000 erected, while the steam jet conveyor could be purchased for about $1800, so it was quite a competitor, though it took the equivalent of three times the power for the same capacity.

Typical Pneumatic Installation

Figure 2 shows one of the early pneumatic installations at a U. S. Naval Supply base. The dust collector is a centrifugal type mounted so the collected dust can be chuted to cars. The positive exhauster is within the house at the right. This installation handled 300 lb per minute with a 30-hp exhauster which maintained a reduction of pressure of 2 lb per sq in. in the tank, or about 7 or 8 oz. at the farthest intake. The noise of the pulsating exhaust was annoying to the personnel, so it was led into a 2 by 2-ft trench with loose planking and sand cover and extending beyond the trestle. Although crude, this muffler was completely effective and created negligible back pressure.

Precautions Necessary in Installing and Operating

If the ashes contain incandescent clinkers, there is some explosion risk in this type of conveyor. The discharge gate at the bottom of the tank

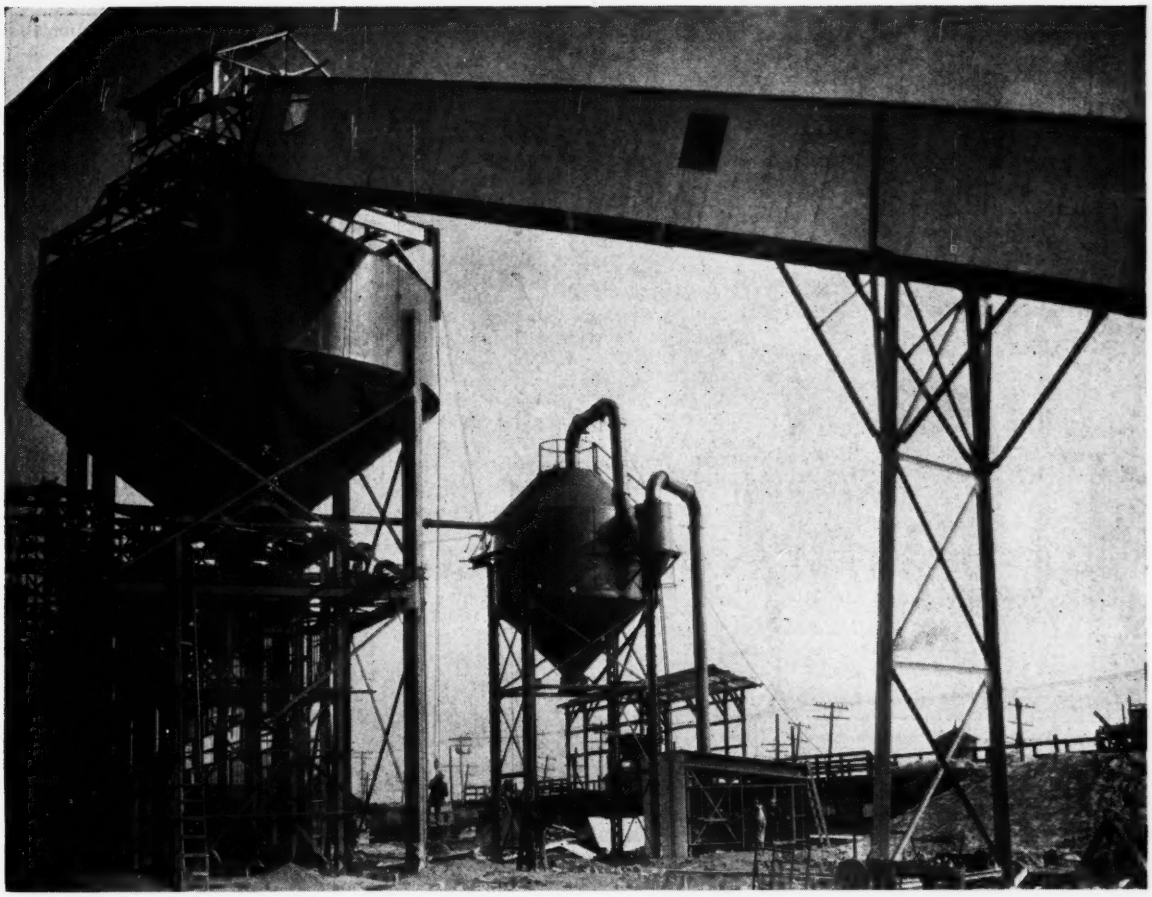


Fig. 2. Pneumatic conveyor, in background, in course of erection at a U.S. Naval Supply Base. In foreground is a 400-ton coal storage bin.

cannot be completely air-tight, so there is some leakage upward. If the water spray should not be turned on, the tank may receive hot clinkers fanned by this fresh air until the gas is ignited. The risk is reduced by interlocking the water valve with the motor switch, and having a large manhole cover on the tank held up by springs until drawn down to its seat when the exhauster starts, though free to blow off.

Even then explosions have occurred —not serious, however. At the Philadelphia Electric Co. the operator found it convenient at night to clean up the basement by sweeping coal siftings into the ash duct. One day the top of the tank blew off and landed on the truck team waiting for a load. At Brooklyn Navy Yard, an explosion occurred which wrecked the dust collector and piping between collector and tank. This was inexplicable until it was found that, when the yard fire protection system was in use, the water pressure was reduced so much that the quenching spray ceased.

Simple Steam Jet System

The actuating unit of the jet system is shown in Fig. 3. The replaceable Monel jet nozzle is located in a recess at the bottom of the elbow, where it is protected from the stream of material. The ashes strike against the wear plate and are sprayed upward with considerable turbulance or eddying, hence the replaceable wear plates just above.

It will be noted that the air blast back of the nozzle is induced by the vacuum-producing action of the jet, and then, positively, by the push of the expanding high velocity steam. Ashes are quenched automatically and the tank or bin need not be air-tight, in fact it must be vented. The ashes in storage usually are too wet because of condensation, and are not easily emptied from the tank. A minimum of 15 lb steam pressure is desirable.

Advantages of Jet System

Although not efficient, the jet system has some very good points. If the ashes can be handled during the noon or evening shut-down periods, the power requirement is not so important since steam which otherwise would, at least in part, be wasted, is utilized. When ashes can be disposed to a waste area, the duct is simply extended toward that point, lengthened from time to time, or switched around, and, if water is injected somewhere along the line, there is very little dust nuisance.

The outstanding advantage of the pneumatic and jet systems is flexibility. The duct can be led along almost any path, bend around corners, rise vertically or on an incline, and, due to the inflow of air at the intake where ashes are fed, there is freedom from dust and gas in the basement. Moreover, there are no moving parts, which always constitute a danger to unskilled men.

Development of the Multijet System

Efforts were directed toward improvement of efficiency as the jet system became increasingly popular. The first improvement located a venturi-type jet fitting in the exhaust line from a closed tank to the stack. While this improved the efficiency, it again introduced the objectionable closed tank. Efficiency eventually was vastly improved by several manufacturers, by locating the venturi jet fitting between a receiver and air washer, and discharging the receiver at intervals into a storage tank beneath.

We will describe one such system.* As shown in Fig. 4, the receiver and washer somewhat resemble a centrifu-

*United Conveyor Corp.

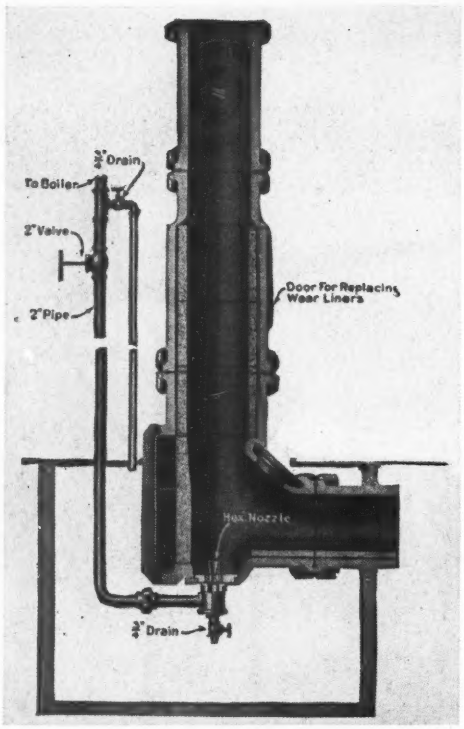


Fig. 3. Actuating unit of steam jet conveyor

gal dust collector, but are of heavy sectional plates. At the bottom of the receiver is a flap gate held shut by the reduction of air pressure within, maintained by an argand venturi fitting between receiver and washer. The material entering the receiver skims around and settles downward. Steam and dust passing into the washer are sprayed with water and drain off to a sewer. A timer opens the steam throttle for 80 seconds, then closes it for 10 seconds. The operation is thus intermittent. Some 300 lb of ashes collect in the receiver, to be dropped into the bin when the throttle closes. The efficiency probably is between that of the pneumatic and single jet systems.

Coal Handling by Pneumatic Conveyor

Coal handling by pneumatic conveyor has few attractive features. The 50-ft-per-sec velocity breaks up the coal into a powder, which generally is undesirable. In the modern pulverized-coal burning plant, it would not be; but pulverized coal is difficult to move from a bunker, especially if damp. The author recalls one installation in Massachusetts where the layout included a short horizontal run, a lift of 40-ft, a horizontal run across an intervening building and a lift of 50-ft to a storage tank. The exhauster was 200 hp and the capacity 40 tons per hour.

A feeder, bucket elevator and inclined belt conveyor using 200 hp would have a capacity of about 1000 tons per hour. Of course, the investment would be much greater. Usually a coal handling scheme involves distribution to a bunker of some length. A pneumatic conveyor cannot do this without considerable complication.

Comment

Disposal of ashes from a plant where mechanical handling is involved is not infrequently difficult. The abrasive and corrosive qualities of the material are bad factors and maintenance costs are high. As compared with a drag chain conveyor and bucket elevator, the jet system has a distinct advantage in that it eliminates danger to the operator, is dustless—at least where the ashes are fed to the duct—and, though the power requirement is much higher than for a conveyor and elevator, this usually is a minor consideration.

REFERENCES:
Power Plant Engineering, Dec., 1943.
Power Plant Engineering, Oct., 1944.
Conveyors and Related Equipment, by Wilbur G. Hudson, John Wiley & Sons, N. Y.

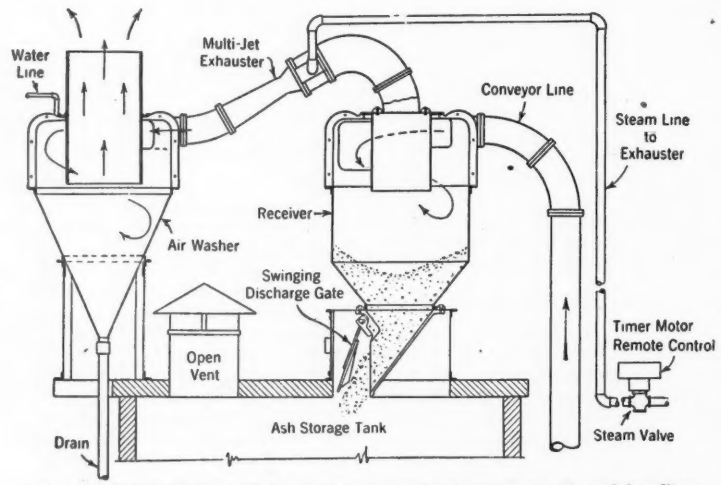


Fig. 4. Actuating unit of the multijet venturi steam pneumatic ash-handling system. Operating cycle is intermittent. Ashes are collected in the receiver mounted above the storage tank, then the exhauster is stopped to allow the batch to drop into storage. Some steam or vapor may escape from the air washer and, if objectionable, the exhaust may be led to the stack.

Quick Stopping for Tap Changers

IN MOTORS that drive switches to change transformer taps under load accurate stopping is as important as the actual operation itself. Tap-changing motors previously have been stopped by a well-designed shoe-type brake. But, friction brakes wear and cannot always be relied upon for consistent performance.

The newest motors developed by Westinghouse don't use friction brakes. They are brought to a stop by plugging, i.e., the power is reversed which causes the motor to try to run in the opposite direction. At the exact instant of stopping the power is disconnected. By this means the motor, running at 3000 rpm, stops in from five to seven revolutions, or about one fifth second.

Mounted on a motor shaft extension, the new switch employs friction drive and stops the motor by electrical plugging action alone. A light, fixed drag prevents drift between operations. A traveling nut provides axial movement of the actuating lever to prevent hunting. Parts are self lubricating and corrosion resistant. Life tests and service records indicate extreme reliability over more operations than expected in the normal life of the equipment of which it is a part.

ASME in its 66th ANNUAL MEETING

By Ralph E. Turner,
Editor, Power Plant Engineering

Society activities indicate progress and financial advancement — Aviation, Materials Handling and Wood Industries Divisions pass quarter century mark — National meetings announced for 1946 — Scientific and engineering progress during war noted — Operating experience with large forced circulation boilers discussed — Progress in metals research reported — Compression distillation, a wartime development — Gas turbine details discussed — Method of estimating fuel requirements for Army camps described — Model smoke ordinance proposed — Fuel powdered by passing through nozzle with steam or compressed air — New engineering materials — Causes and effects of graphitization being studied.

IN THE WAR-IS-OVER spirit, the sixty-sixth annual meeting of the American Society of Mechanical Engineers was held at Hotel Pennsylvania in New York City on November 26 to 29 inclusive, celebrating at the same time the twenty-fifth anniversaries of the Aviation, the Materials Handling and the Wood Industries Divisions.

A veritable flood of ideas, born and grown strong during the years of war, seemed to have broken their bounds and were eagerly sought for possible use by scientists, engineers and industrialists.

Alex D. Bailey of the Commonwealth Edison Co. of Chicago, an eminent power engineer, has for the past year been president of the Society and presided at all executive and several other sessions of the meeting.

While not the largest meeting in number of attendants, more than 3100 registered and nearly 4000 attended at least some portion of the meeting. War restrictions delayed arrangements for this meeting until after V-J day which hurried the preparation and prepublication of some of the papers, but an extremely full program with many simultaneous sessions was carried out substantially as planned. Arrangements are now being made for four national meetings during 1946, as follows: Spring meeting, Chattanooga, April 1-4; Semi-annual, Detroit, June 17-20; Fall, Boston, September 30 to October 3; Annual, New York, December 2-6.

Financially, the Society reports the value of its assets above debts on September 30 amounted to $491,987.56 which the committee believed should carry on the Society's essential activities through a depression period if need occurs.

With the close of the war, this meeting brought out evidence that engineers are not taking up peace-time activities where they were four years ago but several steps advanced, for their participation in the winning of the war has given industry data on the application of scientific and engineering principles that would not likely have been obtainable except under the stress of a nation at war. Outstanding among these developments and advancements are: Atomic energy, gas turbines, rocket planes, synthetic rubber, silicones, control methods, industrial and laboratory instruments, fabrication methods, alloyed metals, lubricants, insulating materials, and wider application of such materials as aluminum, magnesia, plastics, and plywood. All of those subjects came in for discussion, to which should be added such phases of humanics as management, consulting engineering practice, education and training, citizenship and biomechanics.

Fig. 1. President Alex D. Bailey, Vice President in Charge of Engineering, Commonwealth Edison Co., Chicago; Secretary, Clarence E. Davies, Colonel Ordnance Department, USA; President-Elect, D. Robert Yarnall, President, Yarnall-Waring Co., Philadelphia.

Fig. 2. Five of Medalists honored by ASME—Bruce E. DelMar, Dr. Joseph M. Juran, Dr. Sanford A. Moss, William J. King and Dr. William F. Durand.

Forced Circulation Boilers

Engineers who have been looking for operating data on large forced circulation boilers were provided with this data in a paper by G. U. Parks of Montaup Electric Co., W. S. Patterson of Combustion Engineering Co., and W. F. Ryan of Stone and Webster. The unit dealt with is the forced-circulation boiler at Somerset Station which was installed during 1940-42 as part of the topping installation. This and other papers dealing with forced-circulation boilers are printed in abstract on other pages of this issue, but it may be said here that the authors took great pains to describe all sig-

Fig. 3. The society was honored at the dinner by the presence of these four Fifty-Year Members: Arthur L. Rice, Editorial Director of Power Plant Engineering, Chicago; Fred H. Colvin, Editor Emeritus of American Machinist, Point Pleasant, N. J.; John W. Gray, retired, Wayne, Pa.; and Arthur M. Greene, Jr., Dean Emeritus, School of Engineering, Princeton, N. J. The other Fifty-Year Members, not present at the meeting, are J. Francis Booraem, George W. Colles, William S. Conant, Edward R. Gnade, Frederick A. Goetz, George F. Hardy, Albert C. Larkin, Peder Lobben, William E. Mathews, John A. Pilcher, A. M. Robeson, George B. Willcox and Howard E. Williams.

nificant changes that were made and the reasons for making them.

Other papers dealing with this unit related experiences with the feedwater system, the potassium treatment employed and with the instruments and controls.

Opportunity was afforded those who take opposite sides in the matter of boiler water circulation to express their views when a paper on the subject "A Comparison of Operation of Forced and Natural Circulation Boilers" was presented by George F. Ross and Leonard Wilkins who reported upon results obtained by boilers of both types in Coppers Co. Butadiene Division plant at Kobuda, Pa.

Under the auspices of the Power and Fuels Division a symposium was held on reducing losses in power generation and consumption. The intent was to present the manner in which different companies in widely separated fields apply their plant efficiency observations to daily operating practice in the interest of obtaining better operating results. The scheduled speakers were H. D. Hawkins, of E. I. du Pont de Nemours & Co.; Frank L. Brádley, of Forstmann Woolen Co.; O. F. Campbell, of Sinclair Refining Co.; J. R. Michel, of Commonwealth Edison Co., and L. M. Goldsmith, of Atlantic Refining Co. This symposium was the how-to-do-it power session of the meeting.

Metal Research

As power generation has advanced in efficiency, engineers have found this advancement blocked by the inability of available materials to withstand the high temperatures required to accomplish the desired results. The development of alloyed steels has been the answer to many of the needs of industry, but in order to obtain full use of these alloys their physical qualities must be definitely known. Many of the answers have come from the research laboratories of Purdue University and although the work is still going on, the progress made to date was recounted in a paper prepared by J. T. Agnew, G. A. Hawkins and H. L. Solberg.

Their report had to do with their investigation of stress-rupture characteristics of various steels at 1200 F. In these studies the authors dealt with such alloy steels as carbon moly, chrome moly, chrome silicon and tantalum stabilized chrome. These steels were time-tested for corrosion, brittleness, elongation, ductibility and necking characteristics.

Compression Distillation

One of the wartime developments described here for the first time is the Kleinschmidt compression method for distilling water. The paper was presented by Allen Latham, Jr., of Arthur D. Little, Inc., who stated that compression distillation depends upon mechanically compressing the steam or other vapor leaving the evaporation compartment of the still. This compression raises the temperature of the steam a few degrees. At the higher pressure, the steam condenses at a temperature somewhat higher than

Honors and Awards

Asme Medal to
William F. Durand

Holley Medal to
Sanford A. Moss

Worcester Reed Warner Medal to
Joseph M. Juran

Melville Medal to
William J. King

Charles T. Main Award to
Jack Darndell

Junior Award to
Bruce E. DelMar

Undergraduate Student Award to
Ensign John W. Erickson

Honorary Membership to
Rear Admiral Harold G. Bowen
Dugald C. Jackson
Audrey A. Potter
Wong Wen-hao

Thought Provoking Quotes

In my opinion everything possible should be done to preserve the continuity of that team (Science - Industry - Ordnance) in the years of peace which lie ahead.
—Major General G. M. Barnes

The machinery used in the war program was the result of millions of dollars spent on research over the years by the builders of turbines, reduction gears, electrical machinery, boilers, cables, Diesel engines, and many other machinery items.
—Rear Admiral Harold G. Bowen

At sonic and supersonic speeds there is formed in the air in contact with the moving object a shock or compression wave which travels with the object and modifies in extreme degree what may be called aerodynamic form. The laws of fluid flow around the object are profoundly modified, the resistance or drag of the object is greatly increased and the distribution of pressure over its surface undergoes extreme changes. Due to this latter condition, control surfaces, properly adapted for use at normal speeds, may fail utterly to furnish control at sonic and supersonic speeds.
—Dr. William W. Durand

It is difficult, if not impossible, for a superintendent to control the expense in his department if he is not solely responsible for all of it, as well as directly responsible for the excellence of the whole operation.
—H. L. R. Emmet

I believe it is in the national interest to establish a national research foundation composed of the most highly qualified scientists in the United States and charged with the responsibility of furthering basic research and development in all fields of science, and the scientific training of adequate numbers of highly qualified men.
—Lieutenant General Ira C. Eaker

Do not think of rehabilitation solely in terms of the returning veteran. The average ex-serviceman will return an even more desirable employee than when the armed services beckoned. He has been trained, knows the value of loyalty and is in the most employable age group.
—John V. Grimaldi

Because of his training, the engineer is guided by sheer logic and may be counted upon to gather, evaluate and collate the thousands of facts that enter the industrial picture and present them to top management for decision of policy.
—J. P. Kottcamp

Speeds of even 1500 or 2000 miles an hour do not by any means represent the maximum that can be reached with the aid of the jet propulsion motors and engines. When we turn to true rocket motors: that is, to those in which the oxidizer as well as the fuel is supplied as part of the propellant, velocities measured in miles per second, are readily obtainable.
—G. Edward Pendray

We are moving forward toward our goals of full production and full employment. We are moving once again toward a free economy. I am convinced that not many months ahead, the Civilian Production Administration will be able to close its doors, with industry free to go ahead on its own. In all sincerity I think the future looks bright.
—John D. Small

Fig. 4. Lieutenant General Ira C. Eaker, Deputy Commander, Army Air Forces, who addressed the 1500 attending the annual dinner on the subject "Victory Through Air Power."

the boiling point of the evaporating raw water, so that heat can flow from the condensing steam to the raw water and boil it. Power is furnished by a gasoline engine.

Elbow Combustion Chamber

Success of the gas turbine depends upon the successful operation of all its details of construction and one of the most important is the combustion chamber. This was emphasized in the paper by Martin A. Mayers and Wayne W. Carter who described the elbow combustion chamber employed in the gas turbine plant designed and built for the U. S. Navy by the Elliott Co. during the period 1942-44. Among the requirements of this element of the unit was that it was necessary to provide heating of the working medium in two stages, one before the first stage of expansion and a reheat after this; and to reduce the parasitic losses associated with the combustion chambers to a minimum. The process entails the necessity of supplying heat to a flue gas, resulting from the combustion in the initial, or high pressure, combustion chamber, which may contain 2.7 per cent carbon dioxide, 2.6 per cent water vapor, and whose oxygen concentration may be reduced to about 16.5 per cent.

The elbow combustion chamber employed is reported to permit heat release of 25,000,000 Btu per cu ft per hr, with air supplied at 95 psia and 650 F, when it requires a pressure drop of only 16 in. water column; it permits a turndown to 1/20 of full load, and is extremely sensitive to fuel air ratio.

Fuel Use and Preparation

Being one of the largest consumers of fuel in the continental area of the United States, the Army has been confronted with the problem of estimating and evaluating the fuel requirements for the various camps throughout the country. The problem, according to R. E. Biller who is mechanical engineer for the army, is complicated by the fact that camps are located in areas with all gradations between year 'round heating and short seasonal demands, that almost every available type of fuel is used, that the personnel changes continually, that every type of heating equipment is used, and that buildings ranging from permanent hospital structures to tents are heated.

In his paper, Mr. Biller presented a report on the general nature of the attack of the problem, the data collected throughout the study, the methods of analysis of the data, the methods used to evaluate the fuel allowance factors, the results of an analytical survey of the fuel consumption of posts throughout the country to determine from actual consumption statistics the extent to which the original allowances cover the fuel requirements of posts, camps and stations.

As chairman of the Model Smoke Law Committee of the Fuels Division, ASME, John F. Barkley of the U. S. Bureau of Mines, presented a sample ordinance which embraced the creation of a department of smoke regulation headed by a salaried chief smoke regulation engineer who would be assisted in enforcement by an advisory board, most of whom would be engineers and an appeals board. Such an organization would have control over fuel burning equipment.

In a paper by J. I. Yellott and A. D. Singh the results obtained in tests on the process of pulverizing coal by passing it through a nozzle were described. In the process employed steam or air under pressure enters the minute pores of the coal and, when the coal passes almost instantaneously through the nozzle, thus greatly reducing the outside pressure on the coal, the gas which is trapped in the pores expands and powders the coal, the drying is accomplished simultaneously so that the product is obtained in the form of a fine, dry powder. Fineness of pulverization depends upon pressure drop and the ratio of gas flow to solid flow. Results of experiments on bituminous coal, coke breeze, oil shale, and limestone were included in the paper.

Rubber and plastics were among the materials given special attention. In this field new materials, new products and processes are being developed and created almost daily. Among these new materials whose physical prop-

(*Continued on Page* 122)

New Officers for 1946

President—D. Robert Yarnall

Regional Vice Presidents—Alexander R. Stevenson, Jr.; Samuel R. Beitler; J. Calvin Brown; Rudolph F. Gagg; Edward E. Williams and Linn Helander.

Directors-at-large—Edgor J. Kates and J. Noble Landis.

Papers Pertaining To Power Engineering

Operating History of 2000 psi Forced Circulation Boiler at Somerset Station of Montaup Electric Company—G. U. Parks, W. S. Patterson and W. F. Ryan.

Special Studies of the Feedwater-Steam System of the 2000 psi Boiler at Somerset Station of Montaup Electric Company—W. D. Bissell, B. J. Cross and H. E. White.

Results of Potassium Treatment in the 2000 psi Boiler at Somerset Station of Montaup Electric Co.—W. W. Cerna and R. K. Scott.

Experience with Instruments and Control Equipment for 2000 psi Boiler at Somerset Station of Montaup Electric Co.—W. D. Bissell and E. B. Powell.

A Comparison of Operation of Forced and Natural-Circulation Boilers—George F. Ross and Leonard Wilkins.

Stress-Rupture Characteristics of Various Steels at 1200 F—J. T. Agnew, G. A. Hawkins and H. L. Solberg.

Effect of Flow Conditions in Large Ducts on the Performance of Inertia Cinder Catchers—E. W. Bullock an W. B. White.

Compression Distillation—Allen Latham, Jr.

The Control of Fouling Organisms in Fresh and Salt-Water Circuits—John G. Dobson.

Hydraulic Gate Equipment for Recent Projects of the Tennessee Valley Authority—Kenneth C. Roberts.

Coaster Gate and Handling Equipment for River Outlet Conduit at Shasta Dam—Jacob E. Warnock and Howard J. Pound.

Sliding Friction Under Extreme Pressures—S. J. Dokos.

The Influence of Oil-Film Journal Bearings on the Stability of Rotating Machines—A. C. Hagg.

Thermodynamic Properties of Highly Superheated Steam from 1200 F to 2000 F and from 14.7 psi to 900 psi—E. F. Lype, M. Friedman and J. I. Yellott.

A Marine Gas Turbine—Lt. Comdr. A. T. Scott, Ronald B. Smith and C. R. Soderberg.

The Elliott-Lysholm Compressors—W. A. Wilson and J. W. Crocker.

The Elbow Combustion Chamber—M. A. Mayers and Wayne W. Carter.

The Escher Wyss-AK Closed-Cycle Turbine, Its Actual Development and Future Prospects—Dr. Curt Keller.

Estimating and Evaluation Army Fuel Requirements—R. E. Biller.

Example Section for a Smoke Regulation Ordinance by Model Smoke Law Committee—J. F. Barkley, O. F. Campbell, A. G. Christie, W. G. Christy, T. A. Marsh, T. E. Purcell, R. A. Sherman, and R. R. Tucker.

A New Method of Pulverizing and Drying Coal—A. D. Singh and J. I. Yellott.

German Production of Synthetic Liquid Fuels—W. C. Schroeder.

Viscosity of Lubricants under High Pressure—Coordinating the Data from Ten Investigations—Mayo D. Hersey and Richard F. Hopkins.

Di-Methyl Silicone Fluids and their Performance Characteristics in Unilaterally Loaded Journal Bearings—J. E. Brophy, R. O. Militz and W. A. Zisman.

Di-Methyl Silicone Fluide and their Performance Characteristics in Hydraulic Systems—V. Fitzsimmons, D. L. Pickett, R. O. Militz, and W. A. Zisman.

Failure of Ductile Metals in Tension—G. Sachs, J. D. Lubahn, and G. Espey.

Physical Properties of Plaspreg—John Delmonte.

Effect of Molding Pressure and Resin on Results of Short-Time Tests and Fatigue Tests of Compreg—W. N. Findley, W. J. Worley and C. D. Kacalieff.

Advances in Plastics During 1945—R. J. Moore.

Foam Sponge—W. L. Jantzen.

Summary Report of Battelle Graphitization Investigation—S. L. Hoyt, R. D. Williams, and A. M. Hall.

Progress Report for Project No. 29 on Susceptibility of Casting Steels to Graphitization—J. J. Kanter.

Comparative Graphitization of Some Low-carbon Steels with and without Molybdenum and Chromium—G. V. Smith, S. H. Brambir, and W. G. Benz.

Further Observations of Graphitization in Aluminum Killed Carbon Molybdenum Steel Steam Piping—R. W. Emerson and Matthew Morrow.

Graphitization in Some Cast Steels—A. J. Smith, John Urban and J. W. Bolton.

Influence of Heat Treatment upon the Susceptibility to Graphitization of High Aluminum Deoxidized Carbon Molybdenum Steel—F. Eberle.

Lubricants as Engineering Materials—Charles L. Pope.

Mechanical Seal Failures and Their Causes—Douglas R. Lewis.

Correction of Measurement of Power Output of Diesel Engines to Standard Atmospheric Conditions—M. A. Elliott.

How Forced Circulation Boilers Operate

Complete details of performance of 2000-psi Montaup forced-circulation boiler; data on special research work done, from 1942 to present. . . . Comparison of operation of 750-psi forced circulation and natural circulation boilers at Kobuta. . . . First complete reports on these two installations presented before annual meeting of ASME in New York, November 1945. . . . Data on performance of evaporating surfaces, superheaters, reheaters and temperature control, feedwater problems and their solution, circulation, steam purity, capacity and flexibility. . . . Special emphasis on importance of feedwater conditioning and value of hydrogen measurements. Water level stability notable in both installations, also, flexibility in handling load swings and ability to continue generation of steam if a tube fails . . . First utility and industrial boilers of this type in this country . . . Papers abstracted here under Part I and Part II will appear in full in Transactions of the ASME.

I—The 2000-psi Forced-Circulation Boiler at the Somerset Station of Montaup Electric Co.

A—Operating History and Performance

By G. U. PARKS, General Manager, Montaup Electric Co., Fall River, Mass.
W. S. PATTERSON, Assistant Manager, Forced Circulation Boilers, Combustion Engineering Co., New York.
W. F. RYAN, Assistant Engineering Manager, Stone & Webster Engineering Corp., Boston, Mass.

THE FORCED-CIRCULATION boiler at Somerset Station was installed during 1940-42 as part of the topping installation. Initial pressure and temperature were dictated by the necessity of obtaining 25,000 kw by topping a 375-psi 750-F plant. The size and shape of the boiler were determined by the floor space and head room available in a vacant space in the existing boiler room which had been allocated in 1925 to a future boiler of 120,000 lb. per hr. capacity.

The boiler has a guaranteed maximum output of 650,000 lb. per hr. at 960F at the superheat outlet. Drum safety valves are set to blow at 2000 psi. but average drum pressure over an extended period of time has not exceeded 1925 psi. Pressure at the superheater outlet averages approximately 1850 psi, which gives nameplate pressure at the topping turbine throttle. The reheater takes exhaust steam from the topping turbine at 400 psi, 603F, and exhausts to the stations low pressure header at 380 psi, 765F. The boiler and related equipment have been described in detail in other papers.

After three months preliminary operation delivering steam through the by-pass line, the boiler was placed in commercial operation with the turbine on October 26, 1942 and has been taken out of service 54 times from that date to the present time, November 1, 1945.

The longest outages, which are identified by number on Fig. 1, were chargeable to equipment as listed just below the chart.

Operating History and Changes

Evaporating Surface

A furnace tube failure occured within the first two months of preliminary operation. It was in the front wall a short distance below the roof, and in the second tube from the right side wall. A second tube failure occured in January 1943 in the furnace roof in the same tube that had failed previously. The third tube failure occured in February 1943, while this investigation was in progress. This failure was in the left side wall, third tube from the rear wall. Repairs were made by welding and each failure carefully studied.

Each time the boiler had been drained, substantial amounts of foreign matter were found in the orifice

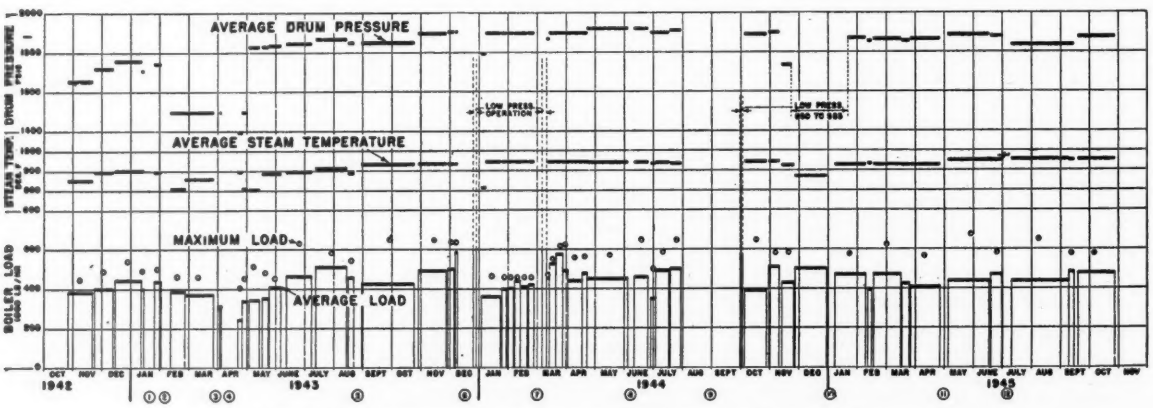

AVERAGE DRUM PRESSURE
AVERAGE STEAM TEMPERATURE
MAXIMUM LOAD
AVERAGE LOAD
LOW PRESS. OPERATION
LOW PRESS. 400 TO 500
DRUM PRESSURE PSIG
STEAM TEMP. DEG. F
BOILER LOAD 1000 LB./HR.
OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV
1942
1943
1944
1945

Fig. 1. Load, temperature, pressure and outage report on Montaup boiler.
The numbered outages are charged as follows:

1. Furnace tube failure
2. Furnace tube failure
3. Research
4. Acid cleaning boiler
5. Miscelaneous boiler changes
6. Furnace tube failure
7. Miscellaneous boiler changes
8. Drum internal changes
9. High pressure turbine overhaul
10. Pressure reducing station
11. Reheater repairs
12. High pressure turbine

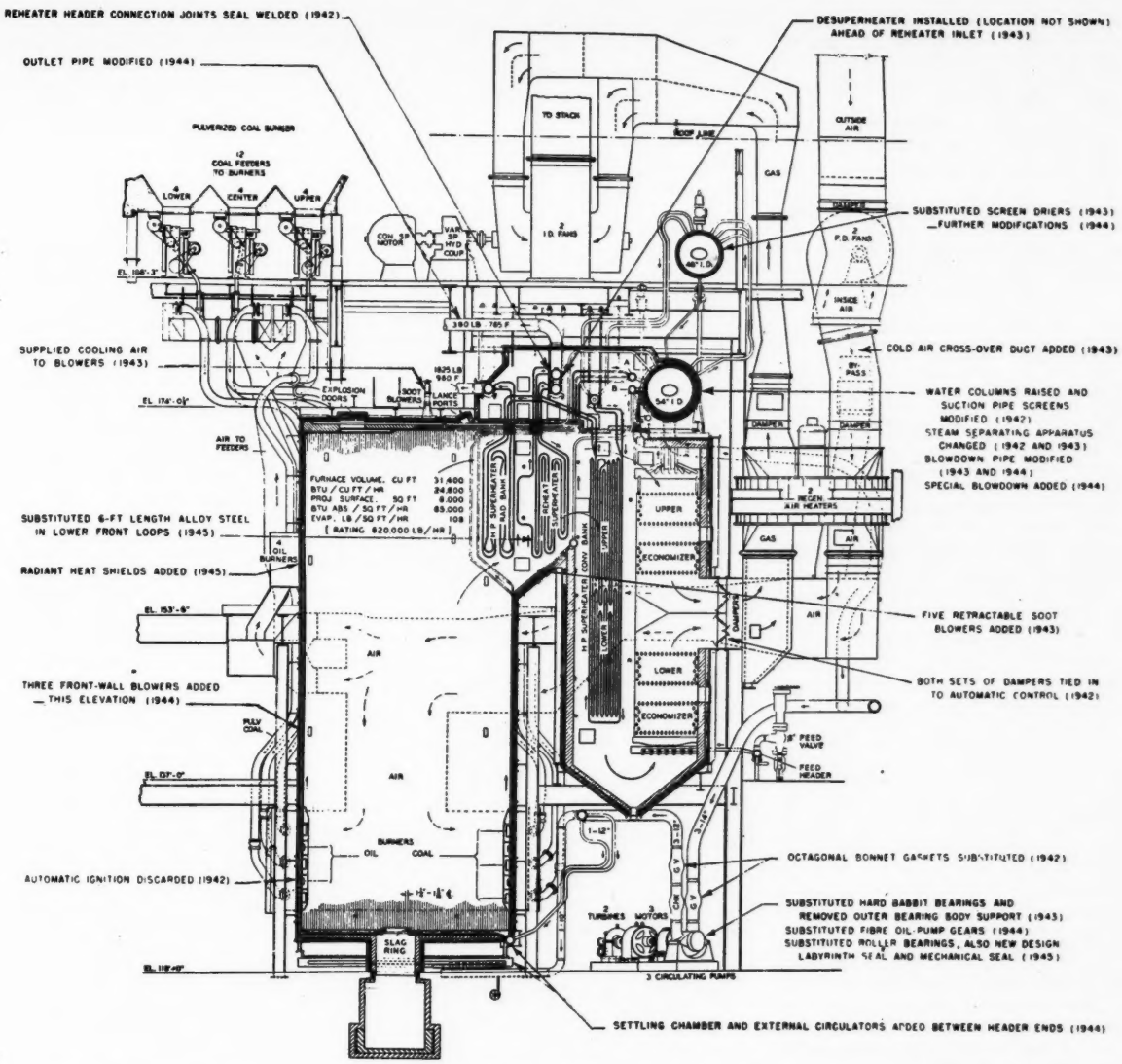

REHEATER HEADER CONNECTION JOINTS SEAL WELDED (1942)
OUTLET PIPE MODIFIED (1944)
DESUPERHEATER INSTALLED (LOCATION NOT SHOWN) AHEAD OF REHEATER INLET (1943)
SUBSTITUTED SCREEN DRIERS (1943)
—FURTHER MODIFICATIONS (1944)
SUPPLIED COOLING AIR TO BLOWERS (1943)
COLD AIR CROSS-OVER DUCT ADDED (1943)
WATER COLUMNS RAISED AND SUCTION PIPE SCREENS MODIFIED (1942)
STEAM SEPARATING APPARATUS CHANGED (1942 AND 1943)
BLOWDOWN PIPE MODIFIED (1943 AND 1944)
SPECIAL BLOWDOWN ADDED (1944)
SUBSTITUTED 6-FT LENGTH ALLOY STEEL IN LOWER FRONT LOOPS (1945)
RADIANT HEAT SHIELDS ADDED (1945)
FIVE RETRACTABLE SOOT BLOWERS ADDED (1943)
BOTH SETS OF DAMPERS TIED IN TO AUTOMATIC CONTROL (1942)
THREE FRONT-WALL BLOWERS ADDED —THIS ELEVATION (1944)
OCTAGONAL BONNET GASKETS SUBSTITUTED (1942)
AUTOMATIC IGNITION DISCARDED (1942)
SUBSTITUTED HARD BABBIT BEARINGS AND REMOVED OUTER BEARING BODY SUPPORT (1943)
SUBSTITUTED FIBRE OIL-PUMP GEARS (1944)
SUBSTITUTED ROLLER BEARINGS, ALSO NEW DESIGN LABYRINTH SEAL AND MECHANICAL SEAL (1945)
SETTLING CHAMBER AND EXTERNAL CIRCULATORS ADDED BETWEEN HEADER ENDS (1944)
PULVERIZED COAL BURNER
12 COAL FEEDERS TO BURNERS
4 LOWER
4 CENTER
4 UPPER
TO STACK
ROOF LINE
OUTSIDE AIR
INSIDE AIR
GAS
AIR
2 I.D. FANS
2 F.D. FANS
2 REGEN. AIR HEATERS
ECONOMIZER
UPPER
LOWER
4 OIL BURNERS
EXPLOSION DOORS
SOOT BLOWERS
LANCE PORTS
FURNACE VOLUME, CU FT 31,400
BTU / CU FT / HR 24,800
PROJ. SURFACE, SQ FT 8,000
BTU ABS / SQ FT / HR 65,000
EVAP. LB / SQ FT / HR 108
(RATING 620,000 LB/HR)
HIGH P. SUPERHEATER
LOW P. SUPERHEATER
H.P. SUPERHEATER CONV. BANK
BOILER
DAMPER
FEED VALVE
FEED HEADER
BURNERS
OIL
COAL
SLAG RING
2 TURBINES
3 MOTORS
3 CIRCULATING PUMPS
EL. 174'-0"
EL. 153'-9"
EL. 137'-0"
EL. 118'-9"

Fig. 2. Arrangement of Montaup boiler unit with changes and modifications from 1942 to 1945 inclusive indicated in notes.

headers, particularly near the ends. There was also evidence of chemical hide-out whenever the boiler was taken off the line.

In order to clean thoroughly tube surfaces and remove mill scale, the boiler was washed with inhibited hydrochloric acid in April 1943. After the acid cleaning, the potassium feedwater treatment developed by Dr. R. E. Hall was introduced.

In December 1943, after seven months operation with potassium treatment including silica feed, the fourth tube failure occured. This was the third failure in the same tube (second tube from the left side wall), and was in the section of the tube which passed across the roof of the furnace. Repeated failures only in tubes served by orifices close to the dead end of the headers indicated the most probable cause to be sludge accumulations at the header ends.

Study of orifice header pressures showed that there was sufficient pressure difference between the rear and the side headers, so 1¼ in. circulators were installed between the rear header and the side headers, each provided with a small baffle settling chamber with sampling connections and blowdown valves and upper closure plugs to permit measuring the depth of sludge in the chambers. They were connected into the existing drain lines, and were blown down once a week as part of the operating routine. Since the headers have been interconnected, very little sludge accumulation within them has been evident.

Since this fourth failure, the potassium treatment of feedwater without silica has been used. Tube samples taken in February of 1944, August of 1944 and September of 1945 from several parts of the walls showed very little sludge accumulation, and what did exist, was not adherent, but easily brushed away. There was evidence of very little, if any, corrosion or pitting of wall surfaces.

On October 26, 1945, about 22 months after the last internal cleaning of the boiler, three small leaks occured in the rear furnace wall, one located less than a foot above the floor and two about 20 ft. above the floor in a different tube. The tubes which had failed were found to be heavily coated with sludge, and on the fire side, iron oxide scale had formed between the sludge and the tube wall, indicating that the sludge had caused overheating of the tubes.

Superheater: High Pressure

There have been no failures, changes or maintenance in either the convection bank or radiant bank.

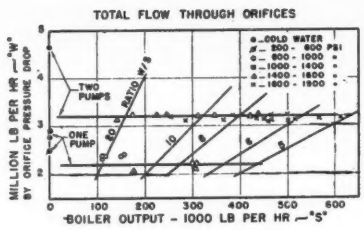


Fig. 3. Total circulation to furnace wall headers based on pressure drop measurements across orifices.

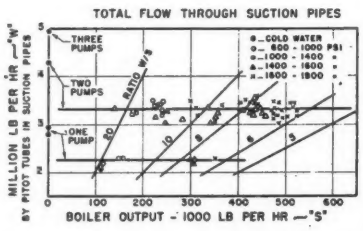


Fig. 4. Total circulation entering pumps based on pressure drop measurements taken on pitot tubes in suction pipes.

Superheater: Reheat

Operation at high rates of output indicated that reheated steam temperatures would be too high at maximum load for continuous operation with carbon-steel reheater elements. It was decided not to reduce the heating surface but rather to correct the difficulty by installation of a manually controlld steam-atomizing spray type desuperheater. This was installed between the H.P. turbine and the reheater in July 1943 and has given very satisfactory control.

Soon after a soot blower overhaul in August 1944, reheater tube failures in the front loop of the reheater began to occur. In April 1945, the lower end of the front loop including the lower bend, of all 58 elements, was replaced with chrome-molybdenum-titanium alloy tube sections about six feet long.

There have been no failures or changes in the economizer. There has also been no maintenance except to seal up a few air leaks at the economizer doors and in the suspended arch where the hanger rods pass through the roof.

Steam Drums and Drum Internals

An entire new set of wet drum internals of the "reversing hood" type was substituted for the original internals in October 1942.

Six open-ended collecting pipes were extended upward above the water level so that concentrated boiler water from the hoods would discharge directly into the collecting pipes. The soot blower steam nozzle was extended to take steam from the drum before it passes through the final drying screens. Gasketted joints in the wet drum were seal-welded at this time. Details of the reasons for these changes are given in the paper.

Excellent steam quality is now obtained from this unit and the results are included elsewhere in this paper.

The air heaters have given excellent service and there has been practically no maintenance.

Soot Blowers

Figure 2 shows the location of the low pressure soot blower elements and also the position of the high pressure retractible blowers located in the roof. In October 1943, air under pressure was piped to these blowers to provide additional cooling.

During the August 1944 annual outage, additional bearings were provided for several of the low pressure elements, particularly in the superheater-reheater zone. Replacement elements with larger nozzles were installed between reheater and front superheater and th wall boxes which were out of alignment were relocated. Operating mechanism of all blowers was overhauled and some changes made to facilitate operation.

With the exception of the slope blowers, there was very little soot blower maintenance during the following year and at the end of that time all of the blowers except those in the slope were still in good condition. The cleaning effectiveness of the blowers as a whole has also been very good since this August 1944 overhaul.

Circulating Pumps

The A pump which had a labyrinth failure in October 1942 had another similar failure in November 1942 and toward the end of December 1942 the labyrinth in the B pump failed. New sleeve bearings were installed in the A and B pumps during January 1943 and the bearings of all three pumps were changed to hard babbitt in February 1943.

Also in March 1943 the A pump labyrinth failed for the third time but the trouble was found to be corrosion or erosion of the casing in the labyrinth section. This was repaired by applying stainless steel and remachining. The other two pumps were overhauled during April and May of 1943 and there were no further failures in the labyrinths.

Miscellaneous: Valves, Piping, Ducts

During the preliminary operation, with frequent starting and shutting down, considerable trouble was encountered due to leaks in the bonnet joints of the large gate valves in the suction and discharge lines of the circulating pumps. Leakage troubles were corrected by changing to gaskets of octagonal section.

There are two forced draft fans and two air heaters with a common preheated air duct below the air heaters. Dampers did not prevent air leakage through to the idle fan, when only one fan was in operation, and burning the paint on the fan. A cross-over duct was installed in 1943 between the cold air outlet ducts of the two fans to correct this condition.

Research and Tests

Circulation

One of the first research studies was to check the total circulation and distribution of circulation to the four separate groups of parallel circuits comprising the four furnace walls. In each wall one circuit had been chosen for installation of a pressure tap on the downstream side of the orifice. The pressure difference between header and the downstream tap beyond the orifice could then be used to determine the rate of flow through the orifice. The pitot tubes in the two suction pipes to the circulating pumps provided another means of determining the total circulation except that this would not include the sealing water which leaks into the pump. Measurement of the pump head provided a third means of checking the pump capacity because a pump characteristic curve had been determined by shop test. A fourth method of checking the total circulation was by determining the difference in solids concentration in the water at pump discharge and leaving the evaporating circuits. It has been shown that the total circulating water flow calculated from the pressure drop across four orifices checks very well with the total flow calculated from pitot tube measurements in the suction pipes. The distribution of circulating water to the walls can therefore be quite accurately determined from the same

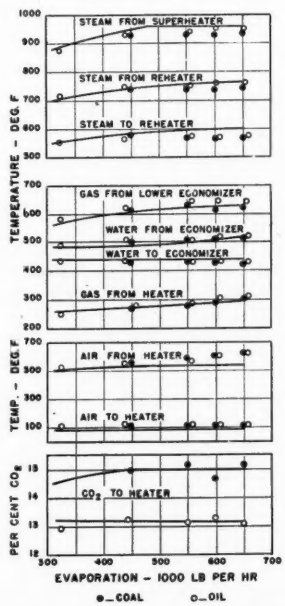


Fig. 5. Results of tests with coal and oil firing compared to predicted performance.

orifice pressure drop measurements and the results of several tests are given.

The distribution of water to the two suction pipes was found to be practically 50-50 when the two outside pumps or the center pump was operating. It was sometimes nearly equal when the center and one of the outside pumps were used, but on other occasions the distribution was 45-55.

A calorimeter was used to check for the presence of steam in the suction pipes. This gives a check on the presence of entrained steam and none could be detected by this method.

(*Continued on page* 124)

B—Special Studies of the Feedwater—Steam System

By

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Montaup Electric Co.

H. E. WHITE
Stone & Webster Enginering Corp.

B. J. CROSS
Combustion Engineering Co.

A SPECIAL study was made on the feedwater and steam system particularly with regard to the dissolution of iron throughout the system and the formation of high iron sludges within the boiler.

The period covered by this work was from January 1944 to October 1945. The boiler was thoroughly cleaned by acid treatment late in December 1943. The boiler water has been continually on potassium salt treatment since May 1943.

Sludge deposits found in the high pressure boiler at the Somerset Station were of particular concern because tube failures that had occurred were attributed to these deposits either on the surfaces of the tubes or on the strainers protecting the orifices in the tube circuits.

The examination of samples of tubes cut from furnace walls at periodic examinations disclosed a thin film of deposit on the entire inner surface of the tube. On the evaporative surfaces the deposit was usually baked on in a semi-scale like form. On the inactive surfaces it occurred as a slime which dried out to a dust. Both types of deposits could be removed with a stiff brush. Slime deposits of sludge also were found in the inlet headers, on orifice strainers and on other surfaces not exposed to external heat. Scale-like flakes of caked sludge have been found lodged in the holes in the strainers. Some of these flakes had a curvature indicating that they had formed in headers or downtake piping. Deposits found in the drum were more granular than those found in the tubes and probably represent the heavier components of the sludge.

The high proportion of iron oxide in these sludges naturally led to some concern; if it were formed entirely within the boiler it might indicate severe local corrosion or pitting that would result ultimately in failure.

The feedwater study may be divided into several phases.

Period 1 (a). Recording hydrogen meters were set up to give a continuous record of the dissolved hydrogen in feed water and in the steam delivered by the boiler. As hydrogen is one of the products of the reaction of water with iron, the amount of hydrogen evolved may be taken as a measure of the rate of corrosion. As irregularities in the performance of the deaerating heater were suspected, a dissolved oxygen meter was also installed to sample the feedwater to the boiler.

The significant feature of these hydrogen curves Fig. 1, is that they show a large part of the hydrogen in the steam enters the boiler with the feedwater. Also there is an indication from the few readings taken that there is an increase in hydrogen across the economizer. Changes in the deaerating system made in the spring of 1944 resulted in consistently good removal of air and since that time the feedwater has been substantially oxygen free.

Period 1 (b). Total solids in feedwater, steam and blowdown. The first approach to the sludge problem was a study of the amounts of total solids delivered to the boiler in the feed water and leaving the boiler with the steam produced and the blowdown removed.

The results of a number of determinations are given in a table with the calculations leading to the total amounts of solids delivered to the boiler and removed from the boiler for a 24 hr. period.

Period 1 (c). Suspended solids in feedwater. It had long been noted that on shutting down the boiler, the water becomes turbid, and that the maximum concentration of suspended solids occurred at the pressure interval of 600 to 400 lb. pressure—this being at the time that the fires were extinguished. Advantage is taken of this period to remove by blowing down much of the accumulated sludge.

A graphic log of a typical shut down is shown in Fig. 2. The boiler had been in operation approximately one week using the B and C circulating pumps.

The reduction in concentration of chloride and sulphate is the result of increased rate of blow down and is a measure of the dilution of boiler water with the increase in feed water rate.

The phosphate does not show a corresponding reduction in concentration indicating a slight "hide out" of that chemical. When corrected for dilution

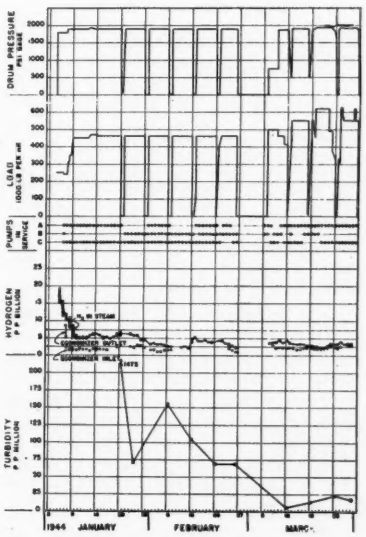

Fig. 1. Hydrogen record, steam flow and boiler pressures for 3 months of 1944 for Montaup boiler.

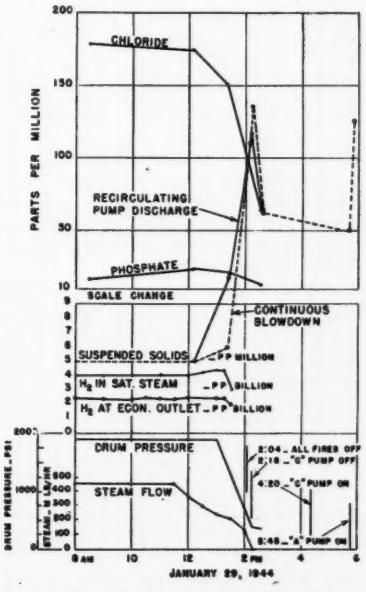

Fig. 2. Graphic log of a typical shut-down of Montaup boiler.

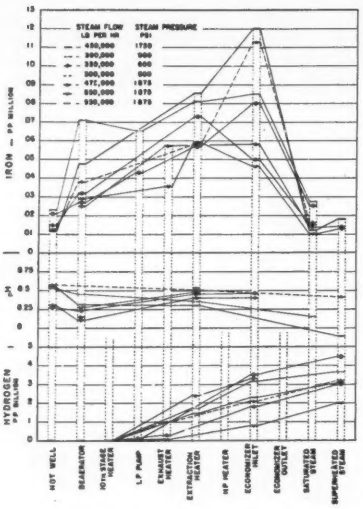

Fig. 3. Results of tests for hydrogen and iron at various parts of water and steam system, Montaup boiler.

a recovery of about one pound of phosphate as PO_4 is indicated. There is also a slight increase in the silica content of the water.

While there is good agreement in the two sets of samples, the circulating pump discharge samples are regarded as the more accurate as the sampling lines were much shorter. The increase in turbidity from 50 to 125 ppm was caused by the sludge that had settled out on the valves at the pump.

The high turbidity of the January 22nd samples which represented a full pressure operating period of about 2 weeks may be attributed at least in part to the effect of the acid wash. The gradual reduction in sludge over the three months period was principally the result of a closer control of condenser leakage and evaporator carryover. Subsequent to this period of operation, sludge collecting chambers installed between the ends of the the rear water wall inlet header and the side wall inlet headers and also a sludge blowdown pipe were installed at the bottom of the main boiler drum. These were blown down once a week and the accumulated sludge thus removed during operation.

Period 1 (d). Gases in steam. The study under item (d) was in greater part unrelated to the work covered in this report. A portion of the program, however, was a measurement of the gases in feed water and steam. The results of these determinations indicated hydrogen values of the same order as those shown by recording instruments.

Period 2. Hydrogen, iron and pH. The work covered by this period was carried on during the interval, October 1944 to April 1945 after two additional hydrogen recorders had been acquired.

While there is wide divergence in values particularly at the economizer inlet, the points of each test form the same general pattern. No relation is evident between the iron content of the water and changes in pressure and boiler load. It may be concluded only that iron and dissolved hydrogen increase together. If we may be permitted to use the average of the rather scattered points for iron values at the economizer inlet, this average value corresponds closely to the amount of hydrogen in the superheated steam. From the equations given earlier, one part per billion of hydrogen is the equivalent of 0.021 parts-per-million of iron. The average hydrogen of the steam is 3.3 ppb corresponding to 0.069 ppm of iron. The average of the economizer feedwater is 0.079 ppm iron. There is as close an agreement as could be expected.

Period 3 (a). Copper in feedwater. The measurement of copper in the feedwater was made because of the presence of that element in all deposits found in the boiler While the amounts of copper reported are quite small, there is a consistent increase across the condenser. The indication of copper in the condensed steam sample is rather surprising. These samples were condensed in a monel coil and there is a possibility of contamination from that source. The comparative tests of monel and steel coils at the deaerator outlet where the sample was only cooled in the coil can not be taken as assurance that there is no contamination under condensing conditions.

It should be noted that there are other possible sources of copper contamination than the condenser that were not investigated.

Period 3 (b). Bead and iron exchange columns. The plating out of iron rich deosits on conductivity cells, glass tubing and rubber tubing through which samples of feedwater and steam were drawn has been observed in a number of plants.

In order to further study this plating out effect bead columns were made up consisting of ½ in. I.D. pyrex tubing packed with ⅛ in. soda glass beads. A synthetic resin ion exchange column operating on hydrogen cycle was prepared and tested together with the bead column.

The principle involved in the plating out effect exemplified in the bead column is not known but is believed to be a surface adsorption effect. The entire feedwater system is undoubtedly lined with this deposit and probably much of the iron deposits noted in the boiler tubes may be accounted for by this property of plating out on all surfaces.

Period 3 (c). Tube temperature measurement. Tube temperature measurements have been reported in another paper of this group.

Period 3 (d). Corrosion detector. In an attempt to obtain a quantitative check on the rate of solution of iron in the feedwater, a corrosion detector was installed in one branch of the boiler feed line leading to the economizer. This detector was recently examined after an exposure of one year. After being carefully cleaned in an ammonium citrate solution, it was found to have lost 0.25 gram of its original weight of 14 grams. This loss if evenly distributed corresponds to 0.0003 in. penetration. There was, however, one small pit of about 0.005 in. depth. The surface was darkened and coated with a powdery film of what appeared to be an iron oxide.

This corrosion detector was returned to its position in the feed line and will be again examined after a period of exposure.

Translated into inches penetration per year over the areas of the preboiler equipment and of the boiler itself, it would not be an impressive figure and would not lead to any great apprehension as to the imminent failure of any part of the equipment. There would, however, be cause for concern if the loss of metal were restricted to local areas such as has been noted in boiler feed pumps. While the hydrogen evolution appears to indicate a greater activity in the high temperature end of the feedwater system, there is no evidence to indicate that localized attack occurs.

The rate of loss of metal from the steam side surface of the condenser tubes as indicated by the measurements of dissolved copper is extremely low. The loss on the cooling water side is probably much greater and also localized attack is known to occur. Failure of condenser tubes is more likely to occur as a result of attack on the cooling water side of the condenser.

One disquieting thing about the dissolution of iron and copper in the feedwater system is that the mechanism of the corrosion is not well understood nor have preventative conditions been well established.

Basically the sludge problem in boilers results from the introduction into the boiler with the feed water of solids or salts that form solids, at a higher rate than the rate of removal. Inevitably this must lead to trouble.

There are two obvious lines of attack on this problem, first, to prevent or minimize the production of the metallic ions, which are the principal components of the sludge in the feedwater system and second, to provide for a better continuous removal of sludge with the blow down from the boiler.

The chances of complete solution of the problem by either or both of these efforts are not particularly promising and it is probable that a periodic cleaning of boilers will be necessary.

C—Water Conditioning for the 2000-psi Boiler

By

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Hall Laboratories, Inc.

R. K. SCOTT
Hall Laboratories, Inc.

WHEN THE BOILER first went into operation in June, 1942, a fairly standard treatment, using sodium chemicals, was used, with the following control limits.

Alkalinity as sodium hydroxide, NaOH, 50-60 ppm

Sodium phosphate, Na_3PO_4, 50-70 ppm

Total Solids, 1000 ppm max.

Some months later it was also decided to feed and maintain a positive reserve of sodium sulphite in the boiler water. During the period this

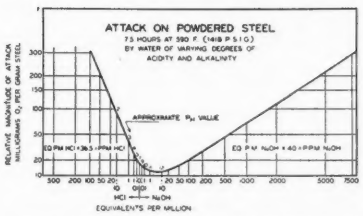
ATTACK ON POWDERED STEEL
73 HOURS AT 590 F. (1418 P.S.I.G.)
BY WATER OF VARYING DEGREES OF
ACIDITY AND ALKALINITY
RELATIVE MAGNITUDE OF ATTACK
MILLIGRAMS O_2 PER GRAM STEEL
APPROXIMATE P_H VALUE
EQ P.M. HCl = 36.5 PPM HCl
EQ P.M. NaOH = 40 PPM NaOH
HCl
NaOH
EQUIVALENTS PER MILLION

Fig. 1. Relative attack of steel at 590 F. by hydrochloric acid and sodium hydroxide (from the laboratory data of Berl and van Taack).

treatment was used, several tube failures occurred, as discussed in the previous paper of this series by Parks, Patterson, and Ryan. Internal boiler conditions were also found unsatisfactory as described in the reference paper by Parks[2]. Evidence of the "hide-out" of sodium sulphate and sodium phosphate was also found which indicated that some of the boiler water was being concentrated very much beyond the limits of the normal overall boiler water.

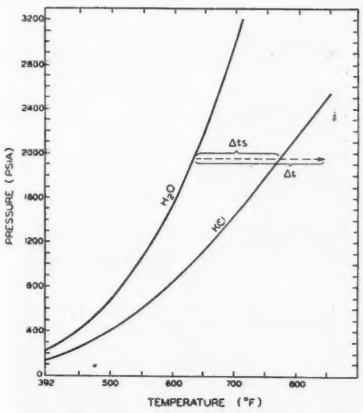

Fig. 2. Vapor-pressure temperature curves of H_2O and saturated solution KCl to illustrate meaning of Δt and Δts.

If the initial concentration were 60 ppm of sodium hydroxide, the water just about to lay down solid sodium sulphate and sodium phosphate at the evaporative surface would necessarily contain 11,000 ppm of sodium hydroxide or a 1.1 per cent solution of NaOH.

In so far as the over-all boiler water was concerned we had protective conditions. But the change which could occur on concentrating the boiler water from 60 ppm. NaOH to 11,000 ppm. NaOH is well illustrated by the curve in Fig. 1, originally developed by Partridge and Hall[4] from the experimental data of Berl and Van Taack[5].

The 11,000 ppm caustic soda solution may seem fancifully high and difficult to attain. Actually, this is not the case. Dissolved substances lower the vapor pressure of a solution at any definite temperature. Correspondingly, under an externally applied temperature increase, the concentration of dissolved solids in a film of boiler water must necessarily increase to maintain constant pressure.

A graphic representation of the meaning of the terms Δt and Δts is given in Fig. 2, which consists simply of the vapor pressure-temperature curves of water and a saturated solution of potassium chloride. The Δt is the difference between the temperature of the concentrating film at the heat transfer surface and the boiling temperature of pure water at the same pressure. The Δts is the Δt which corresponds to the existence of a saturated solution. If Δt is increased beyond this point, a solo solution will evaporate to dryness. Thus, from Fig. 2 the film temperature can exceed the over-all boiler water temperature at 1950 psia by about 140F before potassium chloride will go to dryness in solo solution. At lower film temperature or Δt differential, the film boiler water will simply concentrate to keep its vapor pressure the same as that of the over-all boiler water. If the film temperature or Δt exceeds 140F, the water will evaporate from the solution leaving a dry residue of potassium chloride.

How much Δt would be required to produce the 11,000 ppm, NaOH concentration? The answer is only a little more than 1F. With a Δt of 5F., the film concentration would be about 45,000 ppm (1125 epm.) NaOH, with corrosive action (from Fig. 1) at relatively the same rate as an acid solution of about 300 ppm (8 epm) HCl.

With relatively good circulation such small increases in film temperature, or Δt, and concentrated solutions if soluble solids are present, can occur for at least short periods of time. Examples of such periods would be occasions when the slag falls off of a section of water wall exposing the tubes to higher temperature than the surrounding area.

Fortunately, by the time the need for improving boiler water conditions at Montaup became apparent, considerable of the work developed by Hall had already been made available. Therefore, the boiler was cleaned of existing deposits by means of inhibited acid (Dowell) and a different treatment instituted.

Preliminary Potassium Treating Period

To obtain the advantage of Hall's developments, the boiler water conditioning control started after the acid cleaning in April 1943, was established as follows:

pH value—10.2-10.7
Phosphate (PO_4)—30-50 ppm
Sulphite (SO_3)—2-5 ppm
Silica (SiO_2)—7-10 ppm
K to Na Ratios, equivalents—2:1 Min.
SiO_2 to Alkalinity ratio, equivalents 1.2:1 Max.

Inasmuch as the plant uses tide water for cooling purposes, so that even small amounts of condenser leakage introduced considerable sodium in the boiler water, it was necessary to feed potassium chloride, in addition to the potassium phosphate, sulphite, and silicate, to maintain the desired potassium to sodium ratio.

After the boiler was returned to service with the use of potassium chemicals, one of the most interesting features was the virtual elimination of sulphate and phosphate "hide-out."

Several boiler inspections after relatively short runs, following the use of potassium chemicals, also showed promising results inasmuch as the boiler internals prove to be quite clean. Therefore, the boiler was op-

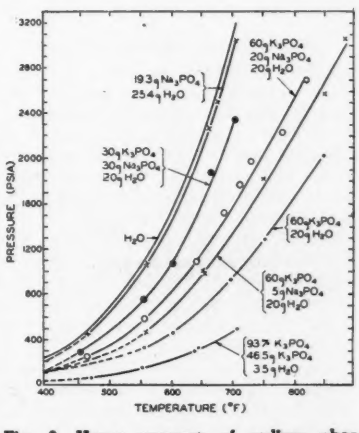

Fig. 3. Vapor pressure of sodium phosphate, potassium phosphate and mixed phosphate solutions.

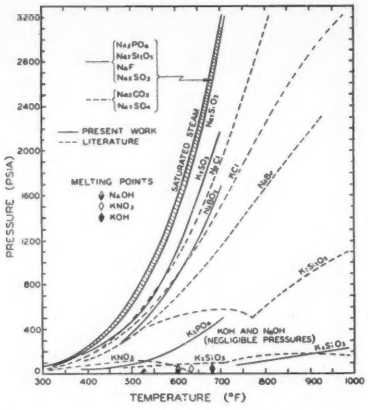

Fig. 4. Vapor pressure of saturated solo solutions.

erated at full design pressure and the maximum load desired by the plant, generally between 550,000 and 600,000 lbs. of steam per hour.

Considerable decomposition of sodium sulphite had been indicated whenever efforts were made to maintain more than a few ppm thereof in the boiler water. In this respect, the potassium sulphite proved similar, and therefore, the decision was made to maintain only a few ppm of sulphite in the boiler water, to serve primarily as an indicator of whether or not dissolved oxygen was entering the boiler with the feedwater.

In December, 1943, number 2 roof tube failed, apparently due to sludge accumulation in the rear wall header around the strainer supplying the orifice which fed this particular tube.

During the period of potassium and silicate treatment the boiler had been operating at full design pressure and had generated considerably more steam with but one tube failure than it had during the period of sodium treatment during which three tube failures had occurred.

The boiler was again acid-washed and the arrangements were also made to interconnect each end of the rear wall header wtih the adjacent side wall header, as described in paper A.

Potassium Treatment in Use Since January 1, 1944

In putting the boiler back on the line, it was decided to discontinue the feed of silica, also to continue with potassium boiler-water treatment because of the lack of "hide-out" when potassium chemicals were used in the boiler-water conditioning.

Results of tests are plotted in Fig. 3, from the data of Kaufman, Marcy, and Trautman. These curves show why "hide-out" is readily obtained with sodium phosphate and not with potassium phosphate.

Figure 4 shows the vapor pressures for a number of solo solutions compared to that of water at various temperatures.

As mentioned in connection with Fig. 3, the Δts of potassium phosphate is so large that it would seem almost impossible to obtain a film temperature sufficiently high to precipitate potassium phosphate out of solution unless actual over-heating of a tube occurs to a considerable degree. With either sodium or potassium hydroxides, concentration of the solution occurs without going to dryness. In other words, in a boiler, or in a water-hydroxide system, Δts is practically non-existent for sodium or potassium hydroxides.

The detailed control limits which were established and have been maintained since January 1, 1944, are as follows:

pH value—9.8-10.4
Phenolphthalein alkalinity (ml., N/30 acid required for 100 ml. sample) —0.5-1.6
Phosphate (PO_4) ppm—8-20
Chloride: Hydroxide ratio, epm—Min.=10:1
Potassium: Sodium ratio, epm — Min.=3:1
Total Solids, ppm—Max.=1000

High Pressure Boiler Feed Water

The boiler feedwater at Montaup is obtained from the turbine condensers plus a small amount of evaporated makeup water. Control to maintain good feedwater conditions is normally maintained at the plant, as proven by some 15 years operation of the 400 psi boilers without difficulty in the preboiler equipment. However, with the coming of the early difficulties encountered in the operation of the high pressure boiler, steps were taken to further improve the quality of the feedwater wherever possible. Operation of the two deaerators was adjusted so that they would always be under positive pressure to assure good elimination of dissolved oxygen. The turbine condensers were also retubed in 1944 to assure minimum contamination by the tide water used for condenser cooling.

These steps have resulted in feed water which generally shows zero values for dissolved oxygen. Carbon dioxide in the system is also very low, due to the feedwater to the evaporators being a sulphate rather than a carbonate water.

Condenser leakage is immediately indicated on the condensate conductivity recorders, and if this becomes at all high, the condenser is taken out of service as soon as possible and the leaking tubes located and plugged. As a result of this control, the turbine condensate used for feedwater has averaged less than 5 micromhos/cm conductivity, since the summer of 1944.

Examination of Boiler Tube Sections

The removal of tube sections for examination rather than merely examination and analysis of such deposits as are found in the wet steam drum, has greatly facilitated the determination of internal conditions of the Montaup boiler. We have thus been able to study the distribution of constituents of the deposit between the fire and cold sides of the tubes, as well as between the surface of the deposit and and the area next to the metal. Examples of this variation are the presence of acmite ($Na_2O.Fe_2O_3.4SiO_2$) on the fire side of some tubes in a thin layer next to the metal. In some instances, this layer was so thin that it would never have been detected had the tube section not been pickled. The bulk of the deposits was iron oxide and contained little or no acmite. Another example is the presence of a considerably higher percentage of phosphate sludge on the cold side of some tubes rather than the fire side. A third example of variation is found in the appearance of the internal surfaces of some tubes. Many of these specimens examined showed smooth, continuous films of magnetic iron oxide, while others exhibited considerable roughness and thicker surface deposit. Pickling of the specimens showed that those tubes which exhibited a rough surface very frequently showed evidence of metal attack. Details of tube examination are given in the paper.

The pictures shown in Fig. 5 are portions of tubes removed from the north wall after approximately 15 months of the present potassium treatment. Tube 134 is one of a pair of tubes being fed through a normal 0.34 in. orifice. It will be noted that the surface of the oxide film is fairly smooth, and that there is no evidence of significant attack on the metal in the pickled specimen, either on the fire or cold side. Tube 138 is one of a pair of tubes being fed by a special 0.50 in. orifice and is similar in appearance to the 134 tube with the normal orifice. Tube 136 is one of a pair

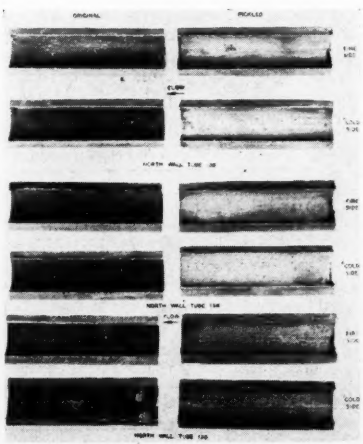

Fig. 5. Appearance of boiler tubes from bifurcated sections after 14 months operation with present potassium treatment. Each tube is one of a pair of bifurcated tubes fed by a single orifice. Tube 138 is fed from a 0.50 in. diameter orifice. Tube 136 is fed from a 0.30 in. diameter orifice. Tube 134 is fed from a 0.34 in. diameter (normal size) orifice.

of tubes being fed by a reduced size orifice, 0.30 in. In the original specimen from this tube, the definite roughening of the surface of the deposit can be noted on both the fire and cold sides. In the pickled specimen there is a little more roughening of the surface on the fire side.

Conclusions

Operation of the Montaup high pressure boiler since April, 1943, when potassium treatment was first instituted has been decidedly successful, with operation at full design pressure and generally near design load as required by the plant.

There have been only two forced boiler outages since April, 1943, associated with internal boiler deposit.

It is felt that the advantages of potassium equilibrium in the boiler water have been definite contributing factors to the operating record of this boiler, similarly to a number of other boilers operating at pressures of 600 psi or above, where definite improvements in internal boiler conditions or maintenance of turbine capacities, or both, have resulted.

D—Experience with Instruments and Control Equipment

By

W. D. BISSELL, Montaup Electric Co.

E. B. POWELL, Stone & Webster Engineering Corp.

INSTRUMENTS and automatic regulating devices which serve for operation control on the 2000-psi Montaup boiler, to be referred to here as boiler 6, are conveniently considered in three groups. In the first group is classed equipment serving primarily for stabilization of output and efficiency of combustion; in the second group, equipment for maintenance of water conditions. For ready identification of equipment associated with the distinguishing characteristics of the boiler, a third grouping is employed for permanent instruments and controls installed to meet the special needs of forced circulation.

The main control panel, mounting instruments and controls primarily of the first group, is shown in Fig. 1.

The flue gas oxygen recorder, one of the highly informative instruments of the board, when purchased had barely passed the experimental development stage. As to be expected with novel equipment, a number of difficulties have been encountered from those frailties which, it seems, experience alone can fully bring to light. The instrument is now to be extensively rebuilt. However, experience has proved the value of this instrument as a guide in control of combustion, giving more definite and precise indication of furnace conditions than the steam flow-air flow recorder which it serves to supplement.

The throttle steam temperature on the low pressure turbines must be held within close limits. Obviously, maintenance of mere constancy of reheated steam temperature would not meet the requirements. Accordingly, manual adjustments are made in desuperheating the low pressure steam prior to reheating, or in automatically controlled temperature of pressure-reduced steam, or in both, as required to give substantially constant temperature at the low pressure turbine throttles.

Superheater steam temperature is controlled by diverting through the upper economizer a part of the combustion gas flow, which would otherwise make full travel of the convection bank of the superheater, by adjustment of main and by-pass dampers at the gas outlet of the economizer. Steam temperature is held very closely, swings in temperature rarely exceeding 5 F even during operation of soot blowers.

As first arranged, air flow for combustion control was evaluated by summation of straight line functions of gas pressure drops across the two parts of the economizer, utilizing connections at points about as indicated by C and D, and E and F in Fig. 3. Attempts toward close co-ordination in combustion control encountered the fact that such factors as flow disturbances varying with the positions of main and by-pass dampers, accumulating deposits on economizer surfaces and flow disturbances from slag and ash accumulations in the superheater and reheater ahead of the economizer, gave an annoying lack of consistency in gas pressure differential in relation to actual rate of gas flow. After exhaustive efforts to improve performance, it was decided to install restricting baffles to form an orifice in the short length of flue between the economizer outlet dampers and the air heater as indicated in Fig. 3.

However, the pressure loss as measured across these restricting baffles was also influenced by the position of the dampers. Use of the air heater pressure differentials was adopted as a last resort. Connections for metering gas flow and the gas flow factor in combustion control were shifted to G and H, Fig. 3. The results have been very promising. The arrangement has now been in operation more than six months and combustion control and air flow measurement have been found

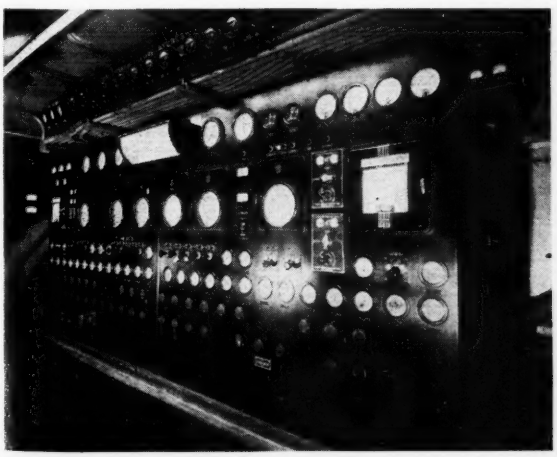

Fig. 1. Main control board for 2000-psi Montaup boiler 6

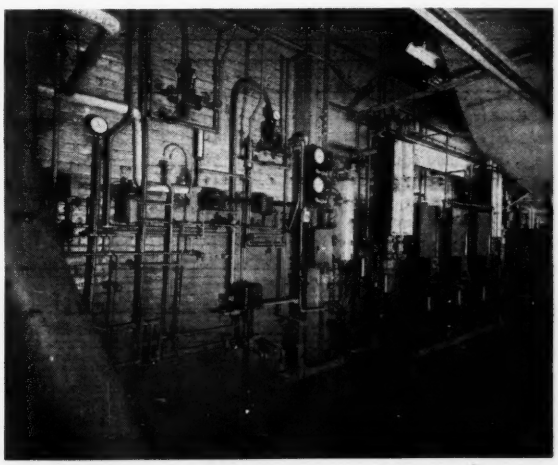

Fig. 2. Hydrogen analyzing blocks, pH and conductivity cells and accessories

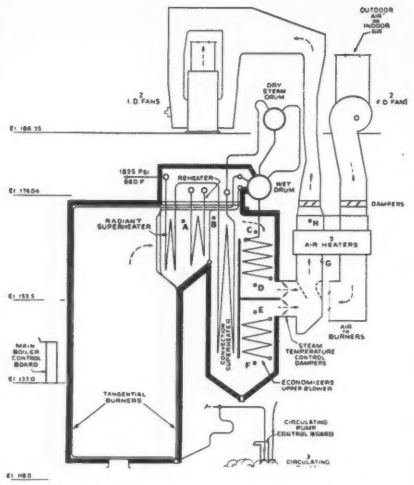

Fig. 3. Diagrammatic section of boiler 6, showing points G and H finally adopted for combustion gas flow measurement

to respond satisfactorily not only to normal fluctuations but in meeting severe sudden changes in load.

Protective devices associated with the combustion control are arranged to give instant stoppage of fuel, coal or oil, on loss of primary air, on excessive back pressure in the furnace, or on failure of both induced draft fans and, under this last condition, forced draft and primary air fans will be tripepd out. The use of controlled circulation requires also that all fuel be instantly cut off on failure of circulation, which in this case is effected by the pressure differential across the circulating pumps on dropping to 20 psi.

Successful operation of automatic controls is inescapably dependent on their conscientious routine inspection and maintenance and, where compressed air is the control impulse fluid as on boiler 6, absolute cleanliness and dryness of air and reliability of air supply are of vital importance.

Control of Water Conditioning

As to be inferred from the other papers of the series, experience with the instruments of group 2 has been of major interest at the station. Preliminary operation of the high pressure unit early demonstrated that the simple daily test routine which had served for the older 375 psi plant was far from meeting the needs of close control of water conditions for boiler 6. More observations and more frequent observations were necessary to avoid too long continuance of contamination or too wide discrepancy between coincident chemical requirements and actual chemical concentrations. Specific factors calling for more prompt detection have included condenser leakage, evaporator carryover, chemical feed variations, change in continuous blowdown recirculation and some factors less usual and less liable to occational occurence have also come to attention.

The relatively high ratio of heat absorbing surface to cross section of circulating path in boiler 6 probably tends more to collection of suspended material and, coupled with the use of restrictive orifices for control of circulation distribution, introduces a somewhat greater than ordinary susceptibility to water conditions. Recording instruments to reveal and identify corrosive and other unfavorable conditions as they occurred seemed of pressing importance.

Hyrogen evolution at the steel surface was believed to give a reliable index of the rate of metal loss in absence of free oxygen in the system. Consequently, among the first of the new instruments selected was a two-point hydrogen single-point oxygen recorder, its commercial development and possibilities having been brought to the attention of one of the authors by Mr. Sheppard T. Powell. Also, for the utmost promptness in detection and identification of departures from scheduled conditions, so to minimize the continuance and effects of water variables, recorders were provided to cover continuously the highly informative test values of high pressure feedwater and boiler water pH and conductivity, and high pressure steam and evaporator vapor conductivity.

It was further recognized that instruments of this class should be under practically constant surveillance of operators who would themselves take any indicated corrective measures or would be in a position promptly to give proper instructions to others.

The high pressure turbine operator makes hourly log of chemical pump operation and continuous blowdown valve settings; also, of recorded high pressure feedwater oxygen and hydrogen concentrations, conductivity, and pH; boiler water conductivity; and superheated steam hydrogen concentration and conductivity. Because of the importance of stability of water conditions in boiler 6, the operator makes hourly tests of the high pressure continuous blowdown water for alkalinity, phosphate concentration, and pH value as running checks on the recorders. With the close observation of water conditions so maintained in such comprehensive scope even a slight change is quickly detected and usually its source rather promptly identified so that, in general, correction can be made before any serious effects have resulted. Much more in this direction can still be done. Meanwhile, the broadened and heightened interest of the turbine operators, and their conscientious follow-up of irregularities observed in water conditions, are worthy of note and emulation.

The more complete daily analysis of high pressure boiler water and boiler feedwater is made by the plant laboratory and these results are used as the overall check on the hourly tests for basic control of water conditioning. Notwithstanding the generally small value of feedwater contamination, the recording instruments give very practical demonstration of the importance of continuity and uniformity in chemical feed.

Under current normal operating

(*Continued on page* 124)

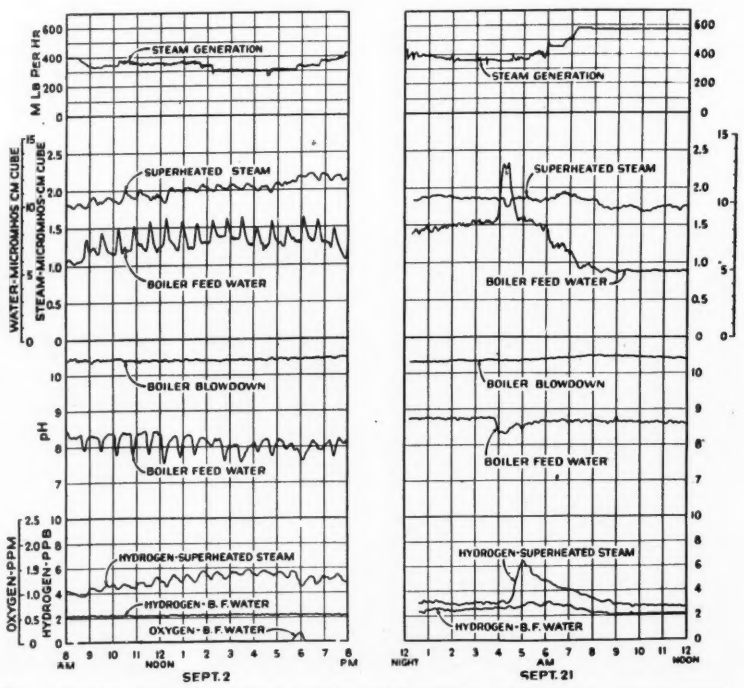

Fig. 4. Graphic logs for September 2 and 21, 1945 showing hydrogen and oxygen records related to other boiler factors

II—Comparison of Forced and Natural Circulation Boilers at Kobuta

By

G. F. ROSS, Asst. Supt. of Utilities, Koppers Co., Inc., Butadiene Division
LEONARD WILKINS, Maintenance Engineer, Koppers Co., Inc., Butadiene Division

INSTALLATION of a controlled forced-circulation boiler unit adjacent to three natural-circulation boiler units of identical rating at the Koppers Co., Inc., Butadiene Division, Butadiene-Styrene Chemical Plant, has afforded boiler operators an opportunity to compare the operating characteristics of these two types of steam-generating units. Boiler designers and operators are naturally interested in the first application in this country of a forced-circulation boiler unit to supply steam for industrial-plant processes. The steam-generating facilities at Kobuta were built at a time when the steel demand for other urgent war needs was at its peak; the Government directed that a forced-circulation boiler unit should be installed. Plant operations began in June, 1943, with one natural-circulation boiler; in August, 1943, the forced-circulation unit was placed in service.

Operating personnel was obtained several months prior to operations, in order that start-up of the boiler units could proceed without delay. Operators observed the complete erection of each boiler unit with its auxiliaries, and supervisors conducted short classes with operators to familiarize them with the operating characteristics of each boiler. The wisdom of such a procedure was illustrated by the ability of the operators to start up each unit as it was completed and maintain it on the line as a reliable steam source for plant process. The start-up of the forced-circulation unit was no more of an event than that of the natural-circulation units, as operators had become accustomed to its unconventional design.

The time limit of construction and operating date prohibited exhaustive studies in layout and operating equipment. That the plant has produced steam consistent with high demand attests to the ability of the designers and operators to meet the wartime limitations.

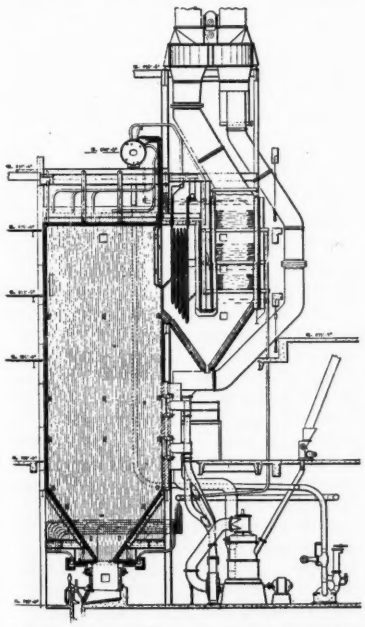

Fig. 1. Cross-section of forced-circulation boiler at Kobuta

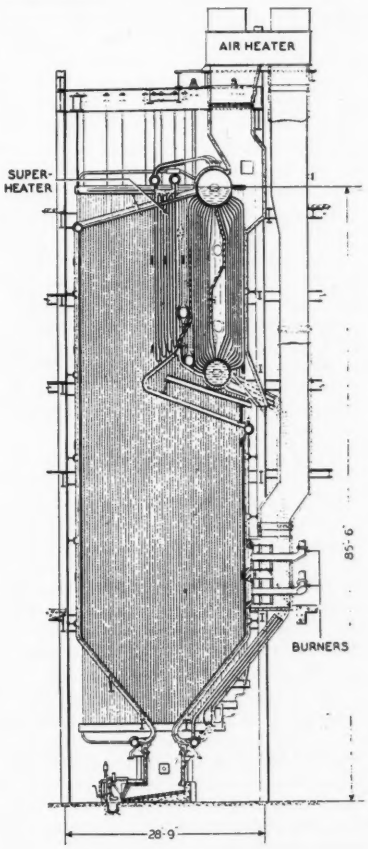

Fig. 2. Cross-section of natural-circulation boiler at Kobuta

Plant & Boiler Auxiliaries

The original steam plant consists of four 350,000 lb per hr boilers, designed for superheater-outlet conditions of 725 psi pressure and 750 F temperature. The first is a Combustion Engineering Co. single-drum controlled forced-circulation boiler, Fig. 1, and the other three are Babcock & Wilcox Co. two-drum radiant-type natural-circulation units, Fig. 2. Operating experience indicated that the capacity of three boilers was not sufficient to supply all the steam demanded by the chemical-process units with one boiler off the line for inspection and maintenance. Accordingly, a fifth boiler of 180,000 lb per hr capacity at 450 psi pressure without superheat was installed. This latest addition is a Combustion Engineering Co. four-drum natural-circulation unit. Total steam-generating capacity available from the five boilers is 1,580,000 lb per hr. The four high-pressure units are housed in a reinforced-concrete boilerhouse, approximately 130 ft high, while the low-pressure unit is installed in a separate annex at the south end of the original concrete boiler room. No further reference will be made to the smaller natural-circulation unit and its auxiliaries.

Draft equipment for each of the high-pressure units is identical, consisting of one induced- and one forced-draft fan per boiler, with turbine drives. Fly-ash collection equipment is within the induced-fan housings, thus minimizing the use of steel. Each boiler is equipped with a Ljungstrom air preheater. A combination of two coal-and-gas, and two coal-and-oil burners fire the forced-circulation boiler. Natural-circulation-boiler furnaces are equipped with six combination coal-and-oil, and two separate gas burners. All furnaces are dry bottom, with intermittent ash-sluicing facilities, and continuous ash sprays. The forced-circulation unit is equipped with two Raymond bowl mills, with integral exhausters, and the natural-circulation units are fired with two Harding-type ball mills, with remote exhausters located on the operating floor. Feed pumps consist of three turbine driven, one motor driven, and one turbine-and-motor dual-drive unit.

Steam at 700 psi and 750 F goes to a 35,000-kw turbogenerator which exhausts at 165 psi backpressure for chemical plant process requirements.

TABLE OF PERFORMANCE DATA OF FORCED-CIRCULATION AND NATURAL-CIRCULATION STEAM GENERATORS

	Forced-circulation unit	Natural-circulation unit
Steam output, lb per hr	352500	345000
Temperature of air for combustion, deg F	90	106.3
Temperature of feedwater to boiler, deg F	472	364
Exit gas—CO_2 content, per cent	14.9	15.2
Heat content of coal (as fired), Btu per lb	13695	13095
Steam pressure, psi	720	722
Air pressure at burners, in. water	1.92	2.8
Draft in furnace, in. water	0.139	0.22
Draft at boiler outlet, in. water	1.9	2.98
Draft at economizer outlet, in. water	4.31	.....
Draft at air-heater outlet, in. water	6.81	10.65
Steam temperature, deg F	726	690
Temperature of air leaving air heater, deg F	574	554
Temperature of gases leaving boiler, deg F	1038	658
Temperature of gases leaving economizer, deg F	697	.....
Temperature of gases leaving air heater, deg F	379	376
Temperature of feedwater entering economizer, deg F	350	.....
Combustion space per lb of coal per hr, cu ft	0.78	0.92
Heat absorbed by water in economizer, Btu per lb	133	.....
Heat absorbed by water and steam in boiler, Btu per lb	742.3	864
Refuse, per cent of fuel (as fired), per cent	11.82	15
Rate of heat absorption per lb of fuel, KB	11.54	10.95
Rate of heat absorption per sq ft of steam generating-unit surface per hour, KB	13.75	11.47
Efficiency of steam-generating unit, per cent	84.3	84.0
Average draft loss, in. water	6.67	10.43
Average air-pressure loss, in. water	5.93	9.65
Steam purity, ppm	0.6	0.7

Steam and feedwater circuits, blowdown system and other auxiliaries are described in detail.

Water-Treating Facilities

Treating-plant equipment and basins are located adjacent to the powerhouse in a separate building and connected to the station by a pipe tunnel. Ohio River water is fed into three Spaulding precipitators in the water-treating plant through a 20-in. line. The treating process is capable of delivering the required boiler make-up water to the boilerhouse with a residual hardness rarely exceeding 2 ppm even during periods of peak hardness of the raw water.

Make-up water is pumped from the soft clearwell to two deaerators located in the boiler plant. Each deaerator is designed to operate at a pressure of 10 psi with a guarantee to remove the oxygen from 900,000 lb of feedwater per hr.

Operating Conditions

The chemical process is extremely sensitive to variations in steam conditions and slight steam upsets curtail chemical production. During boiler difficulties, when generating capacity could not maintain proper steam conditions, operators were reluctant to drop steam delivery to process because subsequent readjustment to normal production rate would require 24 to 48 hr, in addition to entailing large losses of raw materials. The boilers were called upon to recover from adverse conditions promptly and in most cases, boiler operators were able to maintain a continuity of steam flow to the process units.

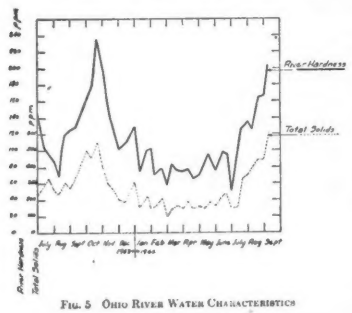

Fig. 5 Ohio River Water Characteristics

Fig. 3. Ohio River water characteristics

In contrast to the operation and performance of a boiler under central-power-station conditions where make-up water rarely exceeds 2 per cent, and where even this amount is supplied by evaporation, boiler make-up here at Kobuta has been of the order of 60 to 70 per cent due to process-steam requirements. These steam requirements necessitate discarding two thirds of the steam condensate in process wastes.

Ohio River water, which is the raw-water source, contains principally sulphate salts and is generally slightly acid in nature, with a pH of 6.5. Total hardness for the major portion of the year ranges between 70 and 90 ppm expressed as calcium carbonate.

Composition of the water is subject to wide variations in hardness and dissolved solids, as shown in Fig. 3.

Normally, moisture content of the coal does not exceed 4 per cent, but there have been periods during transportation difficulties, when 10 to 15 per cent moisture coal has been delivered to the pulverized-fuel equipment; such periods occurring when steaming capacity was at a premium. These periods made it possible to observe the individual boiler response to the demands for steam to process.

That no particular difference between the boiler units was found might be surprising to those who believe that the forced-circulation unit responds and recovers load in less time than the natural-circulation units of the same capacity. With the units equipped with different types of mills, any indication of such conditions might be attributed to the mill performance rather than to that of the boiler.

Local strip-mined coal, ranging in quantities of 25 to 50 per cent of the total fuel, has been fired in all boilers. Two generating-tube failures and severe erosion of generating tubes in the natural-circulation boilers have led several consultants to consider these conditions to be the result of the high silica content of the ash of this strip-mined coal.

Operating Characteristics

The forced-circulation boiler holds approximately 37,000 lb of water at steaming level, compared to the natural-circulation boiler which holds 155,000 lb, or nearly 4¼ times as much. This causes a greater sensitivity in the forced-circulation boiler to changes in feedwater conditions or changes in controls.

With the natural-circulation boiler operated at 350,000 lb of steam per hr for a period of 2 hr with the blowdown completely shut off and with 400 ppm dissolved solids in the feedwater, an increase of 1800 ppm in the solids concentration of the boiler water would result. This added to the normal 2000 ppm carried would mean a total concentration of the boiler water of 3800 ppm. Actual operating data indicate that these boilers can be operated at 400,000 lb per hr with 4000 ppm dissolved solids. Should the continuous blowdown be completely shut off on these natural-circulation boilers, no serious results would be experienced before the boiler operators could remedy the condition.

In the case of the forced-circulation unit under the same conditions, the concentrating effect of evaporation would result in a total dissolved solids content of 9600 ppm. At a steam rate of 350,000 lb per hr, solids carry-over would probably begin with a concentration of 5000 ppm and would doubtless be experienced if the blowdown were stopped for only ½ hr.

To be reasonably free from upsets of the nature described, analyses of the boiler waters are made every 2 hr, total solids being checked by the conductivity method. In so far as the natural-circulation boiler is concerned, this 2-hr frequency is adequate to detect any major change in conditions before the results become serious. Such is not the case in the forced-circulation unit. Carry-over has been experienced on several occasions with the forced-circulation unit as a result of rapid increase in solids concentration, the carry-over being detected by means of the steam-temperature recorder.

Arrangements are being made to install a conductivity recorder on all

(Continued on Page 142)

ATOMICS

A New Section added to POWER PLANT ENGINEERING to cover current and forthcoming developments in atomic energy and related developments and applications in Nuclear Physics

THE DEVELOPMENT OF ATOMIC ENERGY

This is the fourth of a series of articles giving a general account of the development of methods of using atomic energy for military purposes under the auspices of the United States Government. The first three articles, presented respectively in the October, November and December issues describe the fundamental principles involved in the release of nuclear energy and the development of methods and plant for producing plutonium by a self-sustaining nuclear chain reaction. Now, in this article, we describe the methods used and the development of the plants at Oak Ridge, Tennessee, for the large-scale separation of U235 from natural uranium. These articles are based upon the official report by H. D. Smyth, Chairman of the Department of Physics of Princeton University.

By Andrew W. Kramer, *Managing Editor, Power Plant Engineering*

IN THE PRECEDING article in the December issue we described in some detail the principles underlying the design as well as the actual construction features of the large scale plant for the production of plutonium at Pasco, Washington. This plant is known as the Hanford Engineer Works.

Simultaneous with the research on plutonium and the development of the Hanford Engineer Works, work went ahead on the development of large scale methods for separating the isotope U235 from natural uranium. It will be recalled that U235 exists in natural uranium only to the extent of one part in 140.

Also it will be recalled the possibility of producing an atomic bomb using U235 was recognized long before plutonium was ever discovered. It was the fission of U235 that led the scientists to believe that an atomic bomb might be achieved. Later it was found that plutonium (PU239) also was subject to nuclear fission and since this element could be produced by a self-sustaining nuclear chain reaction from U238, plans were made for producing it on a large scale.

In the meantime, however, a great deal of work had been done on the separation of U235. A number of different methods for effecting such separation had been under investigation for a number of years and of these various methods there were four that seemed to offer possibilities for large scale separation. It was to effect this separation that the vast plant known as the Clinton Engineer Works at Oak Ridge, Tennessee, was built. Nearly all of the work done at the Oak Ridge plant was in the separation of U235 from natural uranium. Except for the small "pilot" plant for the production of plutonium at the Clinton Engineer Works (described in the December issue) practically all the equipment at the Tennessee plant was U235 separating equipment. As already mentioned, four methods of separation seemed to offer possibilities of success and work on all four of these methods went on simultaneously. The four methods were: 1, Gaseous diffusion; 2, Centrifugal separation; 3, Thermal diffusion; 4, Magnetic separation.

Factors Affecting the Separation of Isotopes

The isotopes of an element differ in mass but not in chemical properties. For most practical purposes, therefore, the isotopes of an element are separable only by processes depending upon the nuclear mass.

It is well known that the molecules of a gas or liquid are in continual motion and that their average kinetic energy depends only on the temperature, not on the chemical properties of the molecules. Thus in a gas made up of a mixture of two isotopes the average kinetic energy of the light molecules and of the heavy ones is the same. Since the kinetic energy of a molecule is $\frac{1}{2}$ mv^2, where m is the mass and v the speed of the molecule, it is apparent that on the average the speed of a lighter molecule must be greater than that of a heavier molecule. Therefore, at least in principle, any process depending on the average speed of molecules can be used to separate isotopes. Unfortunately, the average speed is inversely proportional to the square root of the mass, so that the difference is very small for the gaseous compound of the uranium isotopes. Also, although the average speeds differ, the ranges of speed show considerable overlap. In the case of the gas, uranium hexafluoride, for example, over 49 per cent of the light

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molecules have speeds as low as those of 50 per cent of the heavy molecules.

Obviously there is no feasible way of applying mechanical forces directly to molecules individually; they cannot be poked with a stick or pulled with a string, but they are subject to gravitational fields, and if ionized, may be affected by electric and magnetic fields. Gravitational forces are, of course, proportional to the mass. In a very high vacuum U235 atoms and U238 atoms would fall with the same acceleration but just as a feather and a stone fall at very different rates in air where there are frictional forces resisting motion, there may be conditions under which a combination of gravitational and opposing intermolecular forces will tend to move heavy atoms differently from light ones. Electric and magnetic fields are more easily controlled than gravitational fields or "pseudogravitational" fields (i.e., centrifugal force fields) and are very effective in separating ions of different masses.

Besides gravitational and electromagnetic forces, there are also interatomic and inter-molecular forces—forces controlling rates of chemical reaction, evaporation processes, etc.

These then are the principal factors that have to be considered in devising separation processes and all of them were considered in the development of the four systems in use at the Oak Ridge Plant.

Gaseous Diffusion

As long ago as 1896, Lord Rayleigh showed that a mixture of two gases of different atomic weight could be partially separated by allowing some of it to diffuse through a porous barrier into an evacuated space. Because of their higher average speed the molecules of the light gas diffuse through the barrier faster so that the gas which has passed through the barrier (i.e., the "diffusate") is enriched in the lighter constituents and the residual gas which has not passed through the barrier is impoverished in the lighter constituent. The gas most highly enriched in the lighter constituent is the so-called "instantaneous diffusate"; it is the part that diffuses before the impoverishment of the residue has become appreciable. If the diffusion process is continued until nearly all of the gas has passed through the barrier, the average enrichment of the diffusate naturally diminishes.

Centrifugal Separation

We have pointed out that gravitational separation of two isotopes might occur since the gravitational forces tending to move molecules downward are proportional to the molecular weights. Since the centrifuge is essentially a method of applying pseudo-gravitational forces of large magnitude, it was early considered a method for separating isotopes. However, the first experiment with centrifuges failed. Later developments of the high-speed centrifuge by J. W. Beams and others led to success. H. C. Urey suggested the use of tall cylindrical centrifuges with counter-current flow. Such centrifuges have been developed successfully.

In such a counter-current centrifuge there is a downward flow of vapor in the outer part of the rotating cylinder, and an upward flow of vapor in the central or axial region. Across the interface region between the two currents there is a constant diffusion of both types of molecules from one current to the other, but the radial force field on the centrifuge acts more strongly on the heavy molecules than on the light ones, so that the concentration of heavy ones increases in the peripheral region and decreases in the axial region, and vice versa for the lighter molecules.

The great appeal of the centrifuge in the separation of heavy isotopes like uranium is that the separation factor depends on the difference between the masses of the two isotopes not on the square root of the ratio of the masses as in the gaseous diffusion method.

Thermal Diffusion

The thermal diffusion method of isotope separation depends upon the fact that if there is a temperature gradient in a mixed gas, there is a tendency for one type of molecule to concentrate in the cold region and the other in the hot region. This tendency depends not only on the molecular weight but also on the forces between the molecules. If the gas is a mixture of two isotopes, the heavier isotope may accumulate at the hot region or the cold region or not at all, depending on the nature of the intermolecular forces.

Such thermal diffusion effects were first used to separate isotopes by H. Clusius and G. Dickel in Germany in 1938. They built a vertical tube containing a heated wire stretched along the axis of the tube and producing a temperature difference of about 600 deg C between the axis and the periphery. The effect was two-fold — in the first place the heavy isotopes (in the substances they studied) became concentrated near the cool outer wall and in the second place the cool gas on the outside tended to sink while the hot gas at the axis tended to rise. Thus thermal convection set up the counter-current flow and thermal diffusion caused the preferential flow of the heavy molecules outward across the interface between the two currents.

The theory of thermal diffusion in gases is intricate enough; that of thermal diffusion in liquids is practically impossible. A separation effect does exist, however, and has been used successfully to separate the light and heavy uranium hexafluorides.

The Electromagnetic Method and its Limitations

In the electromagnetic method of isotope separation, ionized molecules or atoms are accelerated by an electric field and then subjected to a powerful magnetic field which causes them to move in semi-circular paths. The principle is best explained by the diagram Fig. 2 which represents a simple type of mass spectograph first used by A. J. Dempster in 1918. The gaseous compound to be separated is introduced in the ion source where some of its molecules are ionized in an electric discharge. Some of these ions go through the slit S_1. Between S_1 and S_2 they are accelerated by an electric field

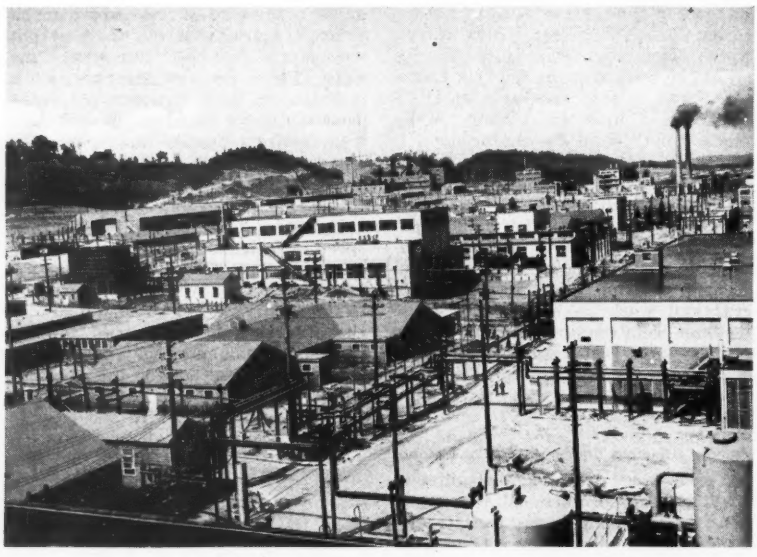

Fig. 1. A view of one of the gigantic production areas at the Clinton Engineer Works at Oak Ridge, Tenn.

which gives them all practically the same kinetic energy. The lighter ions must have less momenta than the heavy ones. Entering the magnetic field at the slit S_2 all the ions will move perpendicular to the magnetic field in semicircular paths of radii proportional to their momenta. Therefore, the light ions will move in smaller semicircles and with proper positioning of the collector only the light ions will be collected.

As will be evident, this method of separation is simple and is, in fact, the best method available for determining the relative abundance of many types of isotopes. It makes an excellent mass spectograph. Unfortunately, however, the ordinary mass spectograph can handle only very minute quantities of material, usually of the order of fractions of a microgram per hour, and this seemed to limit its use in large scale separation processes such as were necessary for the separation of U235 in quantities sufficient for the production of an atomic bomb. There are three reasons for this limitation—first, it is difficult to produce large quantities of gaseous ions; second, a sharply limited ion beam is usually employed (as in the case shown) so that only a fraction of the ions produced are used; third, too great densities of ions in a beam can cause space charge effects which interwere with the separating action. Electromagnetic methods developed before 1941 had very high separation factors but very low yields and efficiencies. These were the reasons which —before the summer of 1941—led the uranium committee to exclude such methods for large scale separation of U235. Since that time, it has been shown that the limitations are not insuperable. In fact, the first appreciable size of samples of pure U235 were produced by an electromagnetic separator.

General Consideration of Separation Methods

For a long time in the early days of the project, the gaseous diffusion method and the centrifuge method were considered the two separation methods most likely to succeed with uranium. Both were going to be difficult to realize on a large scale. As will be described, the gaseous diffusion method was developed to a highly successful degree but the centrifuge method never reached the stage of large scale production. A pilot plant was authorized and constructed and while it operated successfully and gave the degree of separation predicted by theory, it was later shut down and work on the centrifuge method discontinued.

All of the four methods described, together with two others, had been tried with some success before 1940, but none on a large scale and none had been used for uranium. The problem of developing any or all of the separation methods was not a scientific one of principle but a technical one of scale and cost.

Separation of Uranium Isotopes by Gaseous Diffusion

It was in February, 1940, that small amounts of concentrated fractions of the three uranium isotopes of masses 234, 235 and 238 were obtained by A. O. Nier using his mass spectrometer and were turned over to E. T. Booth, A. Von Grosse and J. R. Dunning for investigation with the Columbia University Cyclotron. These men soon demonstrated that U235 was the isotope susceptible to fission by thermal neutrons. It was natural, therefore, that this group under the leadership of Dunning became more interested than ever in the large scale separation of the uranium isotopes. From the first, the gaseous diffusion method was given serious consideration by this group and from that time until February, 1945, the Columbia University laboratory gave most of its efforts to this method of separation. On March 1, 1945, the laboratory was taken over from Columbia by Carbide & Carbon Chemical Corp. Early in 1942 the M. W. Kellogg Co. was brought in to develop plans for large scale production of diffusion plant equipment and eventually to build a full scale plant. To carry out this undertaking a new subsidiary company was formed called the Kellex Corp. In January, 1943, Carbide & Carbon Chemical Corp. was given the responsibility for operating the plant. The decision as to scale and location of the plant was not made until the winter of 1942-43, about the same time as the corresponding decisions were being made for the plutonium production plant.

The general objective of the large scale gaseous diffusion plant was the production each day of a specified number of grams of uranium containing of the order of 10 times as much U235 as is present in the same quantity of natural uranium. Uranium being a solid, the first problem was that of transforming it into a gas for utility in a gas diffusion process. This meant selecting a compound of uranium with some other element which would be gaseous at normal temperatures and from which elemental uranium could be readily regained after diffusion. Among other gases a great amount of experimentation was devoted to uranium hexafluoride, UF_6. Fluorine, having only one isotope, was particularly adaptable because it would not complicate the separation by adding new combinations diffusing at varying speeds. Like most fluorine compounds, it was highly reactive, physiologically poisonous, and introduced severe problems of corrosion in production and handling. Uranium hexafluoride was, nevertheless, selected as the suitable process gas, but since it was so highly reactive and since it is actually a solid at room temperatures and atmospheric pressure, a

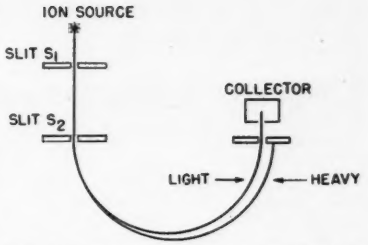

Fig. 2. Diagram showing the principle of isotope separation by the electromagnetic method

study of other gaseous compounds of uranium was urgently undertaken. It was evident from the first that a large number of diffusion stages would be required. Estimates were made that called for *several thousand stages.* There was also to be a "stripping" cascade of several hundred stages, the exact number depending upon how much unseparated U235 could economically be allowed to go to waste.

It is not possible here in this limited space to describe all the details, all the countless problems, the thousands of obstacles that had to be overcome in the design and construction of these plants. Actually it necessitated the creation of the *largest continuous chemico-physical process in the world. A* single process employing more pumps, more diffusion barriers, more power, more instruments and on which was concentrated more intensive research and money than has ever been expended before on a single project.

Totalling about 70 buildings and sprawling over 600 acres at Oak Ridge, a $500,000,000 plant was built, creating almost overnight an entirely new industry based on gaseous diffusion through porous barriers.

The principle behind the separation of U235 from natural uranium was to convert the solid metal into a gas and make use of the difference in velocities of the two principle isotopes U235 and U238 in diffusing through a porous barrier. U235, being the lighter, has a faster diffusion velocity and so the gas initially diffused through the barrier is richer in U235 than the feed gas. After passing through thousands of such stages an appreciable concentration is effected.

As an example of the problems imposed in the design and construction of the equipment, consider the design of the barriers. First a high degree of porosity had to be maintained to permit the diffusion of huge volumes of gas. Yet, to satisfy the theoretical consideration the billions of holes had to be smaller than 0.01 micron (about two millionths of an inch). Second, these pores could not become enlarged

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Fig. 3. An air view of one of the great production plants at the Clinton Engineer Works

or plugged up as the result of direct corrosion or dust coming from corrosion elsewhere in the system. And despite the high degree of porosity the barriers had to be strong enough to withstand a pressure head of 15 lb per sq in. But finally, and to top it all off, the material had to be amenable to manufacture in large quantities (measured in acres), and with uniform quality. It was certainly a large order to throw in the lap of any group of engineers. No solution was forthcoming for some time after actual construction had begun on the gaseous diffusion plant. Nevertheless, work on all other phases of the job was continued while research on the barrier problem was intensified. It was assumed that satisfactory barriers would be ready at the proper time, and they were.

Altogether the history of barrier development is similar to that of the history of the canning problem of the plutonium project. In each case the methods were largely cut and try and satisfactory, or nearly satisfactory, solutions were repeatedly announced, but in each case a really satisfactory solution was not found until the last minute, and then proved to be far better than had been hoped.

Pumping and Power Requirements

Another phase of the work which involved a tremendous amount of effort and research was that having to do with the pumping requirements. In any given stage approximately half of the material entering the stage passes through the barrier and on to the next higher stage, while the other half passes back to the next lower stage. The diffused half is at low pressure and must be pumped through high pressure before feeding into the next stage. Even the undiffused portion emerges at somewhat lower pressure than it entered and cannot be fed back to the lower stage without pumping. Thus the total quantity of gas per stage comprising twice the amount which flows through the barrier has to be circulated by means of pumps.

Since the flow of gas through a stage varies greatly with the position of the stage in the cascade, the pumps also vary greatly in size or number from stage to stage. The type and capacity of the pump required for a given stage depends not only on the weight of the gas to be moved but on the pressure rise required. It was estimated that thousands of pumps would be needed and that thousands of kilowatts would be required for their operation. Since an unavoidable concomitant of pumping gas is heating it, it was evident that a large cooling system would have to be provided. By early 1942 a good deal of preliminary work had been done on the pumps. Centrifugal pumps looked attractive in spite of the problem of sealing their shafts. But further experimental work was planned on completely sealed pumps of various types.

It should be remembered that these pumps had to be operated under reduced pressure, could not leak or corrode and had to have as small a volume as possible. Many different types of centrifugal blower pumps and reciprocating pumps were tried. In one of the pumps for the larger stages, the impeller is driven through a coupling containing a very novel and ingenuous type of seal. Another type of pump is completely enclosed, its centrifugal impeller and rotor being run from the outside by induction.

All this construction on these plants had to be done without pilot plants. That is to say, there was no small scale separation set up using the identical types of blowers, barriers, barrier mountings, cooling, etc., that were put into the main plant. Such a system could not be set up because the various elements of the plant were not all available prior to the construction of the plant itself. To proceed with the construction of the full scale plant under these circumstances required the utmost in foresight and boldness.

The supply of power for the operation of the diffusion plant was a major problem in itself. Construction of the steam power plant for the diffusion plant began on June 1, 1943. It is one of the largest such power plants ever built. Construction of other major buildings and plants started between August 29, 1943, and September 10, 1943. For the men working on gaseous diffusion it was a long pull from 1940 to 1945, not lightened by such exciting half-way marks as the first chain reacting pile at Chicago. Perhaps more than any other group in the project, those who worked on the gaseous diffusion principle deserve credit for courage and persistence as well as scientific and technical ability. The plant was put into successful operation before the summer of 1945.

The Electromagnetic Separation of Uranium Isotopes

The possibility of large scale separation of the uranium isotopes by electromagnetic means was suggested in the fall of 1941 by E. O. Lawrence of the University of California and H. D. Smyth of Princeton University. We have already pointed out that the first samples of U235 to be separated from natural uranium were obtained by means of the mass spectograph by Professor Nier.

Of the many electromagnetic schemes suggested, three soon were recognized as being the most promising. The "calutron" mass separator, the magnetron type separator later developed into the "ionic centrifuge," and the "isotron" method of bunching a beam of ions. After the first few weeks by far the greatest effort was put on the calutron. The name calutron represented a contraction of "California University cyclotron."

In September, 1942, both the gaseous diffusion and the centrifugal methods of uranium isotope separation had been under intensive study. Both of these methods looked feasible for large scale production of U235, but it was realized that both would require hundreds of stages to achieve large-scale operation. Neither method had actually produced any appreciable amounts of separated U235. In the case of the electromagnetic method, however, after the successful separation of milligram amounts there was no question as to the scientific feasibility of this method. If one unit

could separate ten milligrams a day, 100 million units could separate one ton a day. The questions were of cost and time. Each unit was to be a complicated electromagnetic device requiring high vacuum, high voltages and intense magnetic fields and a great deal of research and development work would be required before complete large-scale units could be constructed. Many skilled operators would probably be needed. Altogether, at that time, it looked very expensive but it also looked certain and relatively quick.

At Berkeley after some weeks of planning, the 37-inch cyclotron was dismantled on November 24, 1941, and its magnet was used to produce the magnetic field required in the calutron. An ion source consisting of an electron beam, traversing the vapor of a uranium salt, was set up corresponding to the ion source shown in the drawing Fig. 2. Ions were then accelerated to the slit S^2 through which they passed into the separating region where the magnetic field bent their paths into semicircles terminating at the collector slit. By December 1, 1941, molecular ion beams from the residual gas were obtained and shortly thereafter the beam consisting of singly charged uranium ions was brought up to an appreciable strength. It was found that a considerable proportion of the ions leaving the source were uranium ions. First experiments with this equipment showed only a small separation factor, but by the middle of January, 1942, a run had been made with a reasonable beam strength and an aggregate flow or through-put of appreciable amount which showed a much improved separation factor. By early February, 1942, beams of much greater strength were obtained and Lawrence reported that good separation factors were obtainable with such beams. By early March, 1942, the ion current had been raised still further. This work made it clear that the calutron was potentially able to affect much larger scale separations than had ever before been approached by an electromagnetic method.

On the basis of this and other work in September, 1942, a recommendation was made by the Army that an electromagnetic separation plant be built at the Tennessee Valley site, that is at the Clinton Engineer Works. Originally it was planned that a pilot plant be built first, but such a pilot plant was never built. Construction went ahead at once on the full-scale plant which later on effected considerable separation of U235.

The amount of work involved in the construction of this electromagnetic plant can hardly be appreciated. One of the important parts of the work was the design and construction of the production magnets themselves. These were huge structures 250 ft long which contained thousands of tons of steel, each of the highest permeability. Prior to their construction the largest magnet in existence was undoubtedly that of the 184-inch cyclotron at Berkeley. At the Tennessee Plant it was required that they design and build magnets nearly 100 times as large. One of the problems in connection with the magnet design was that of carrying on operations in the strong magnetic fields which surrounded each of the magnets. This magnetic force was so strong that when a ten-penny nail was held in the hand a strong effort was necessary to prevent the wrist from being twisted. The pull on the nails in the heels of a pair of shoes was strong enough to make walking difficult. An ordinary wrench or a piece of pipe would either be wrested from a workman's hand or if he held on to it, it would be drawn against the magnet face and his knuckles skinned. To counteract this, all movable equipment and structures that came within the range of the magnetic field had to be built of non-ferrous metals or of non-magnetic steel. This made it impossible to use standard designs for any of this equipment. Large quantities of stainless and other non-magnetic steels had to be procured at a time when they were badly needed for other parts of the war program. Workmen in many shops had to be trained in the welding of these materials and heat treating them, and hardening and working with them in many other ways. A complete set of small tools of beryllium copper had to be designed and produced. Electrical control problems were unprecedented and unique.

Another interesting feature of the plant at Oak Ridge was the use of silver instead of copper for electrical conductors. In all, 14,000 tons of silver, having a value of over $400,000,000, were used. The silver was borrowed from the United States Treasury, was delivered in ingots to copper rolling mills, where it was rolled into strips. These were later welded together with silver solder into conductors of requisite length. The entire operation was under continuous surveillance of Army officers and the work was so well done that every ounce of silver taken from the Treasury vaults has been accounted for.

The electromagnetic separation plant was in large-scale operation during the winter of 1944-45 and produced U235 of sufficient purity for use in atomic bombs. Its operating efficiency is being continually improved. Research work is continuing although on a reduced scale.

There were, of course, many other engineering problems introduced in both the construction and operation of these plants for producing U235. What was necessary was a plant which could operate continuously for 24 hours per day and 365 days per

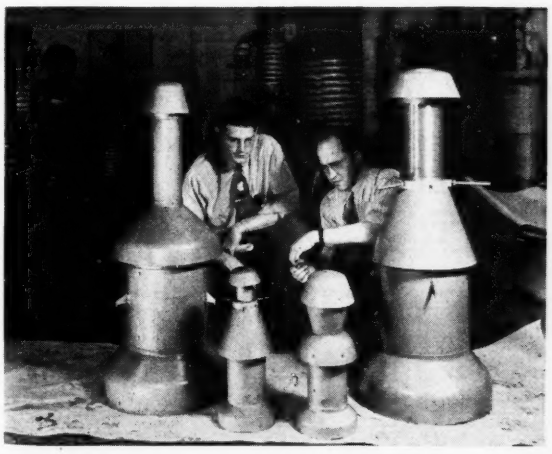

Fig. 4. The high-vacuum diffusion pump developed by Westinghouse.

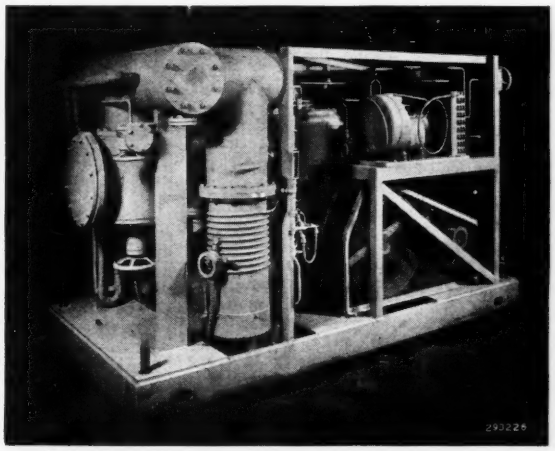

Fig. 5. Complete assembly of gas-diffusion pump

year. These demands involved the introduction of many provisions which scientists did not have to consider at all. Among these may be mentioned water, air and oil cooling of various parts of the magnet, development of quick detachable pipe and electrical connections, development of equipment for quickly detecting leaks, even of microscopic size, into the vacuum chambers. Provision for maintaining coolant solutions at specified dielectric strengths and servicing and repair facilities for the principal operating units involved in the process.

During the operating period not all of the feed material is separated into its component isotopes. A considerable proportion of it goes astray and has to be recovered from the interior walls of the containing vessels and from parts of the operating equipment. Another complication was introduced by the fact that the energy of the ionized particles is so great that those which go astray and which impact on various parts of the apparatus combine either chemically or physically with the metal forming those parts. The result is that a large operating area must be provided for washing and cleaning operations in which all parts of the operating apparatus are cleaned with steam, acid, and in some cases by an electro-stripping process.

One of the interesting things about the chemical operation is the precaution which was taken to salvage every possible grain of uranium whose 235 content has been enriched. It is only by such precautions that the plant capacity is kept up to rating. Some of the precautions are interesting. One is the recovery of splashings from the uniforms of operators in the chemical area. In the cleaning process there is inevitably some splash and drops of uranium solution are absorbed by the operators' clothing. To recover this, the uniforms are washed every day in small laundries in the individual buildings. The wash water is saved and treated for the recovery of its uranium content. When the uniforms are worn out they are collected and sent to an incinerator building where they are burned and the ashes digested with acid and treated for uranium recovery. Shoes of the operators are similarly treated. They are periodically collected and likewise burned in the incinerators.

Atomic Energy was Used to Start Radio Station in 1940

Article published in Power Plant Engineering in October 1940 shows that the fission of U-235 was well known in 1940 and actually used in starting the then new 50,000 watt transmitter at Westinghouse Radio Station WBZ

THE DIAGRAM shown herewith is reprinted from a short article which appeared on page 103 of the October 1940 issue of POWER PLANT ENGINEERING. It shows an arrangement for using nuclear energy to start up a new radio transmitter that Westinghouse had built at Station WBZ near Boston.

Quoting from this article, "During a special ceremony at the new transmitting station in Hull across the harbor from Boston, the explosive force of a single atom of U235 was released by Dr. Condon, associate director of Westinghouse Research Laboratories, to start a chain of electrical reactions ending in switching on the new transmitter.

"The splitting of the uranium atom was clearly audible to the radio audiences as a sharp click. Two preliminary clicks were hear as two atoms were split to accustom the listener to the sound. On the third click the 200,000,000 electron-volts of the split U235 atom switched the program from Millis to the new transmitter in Hull. The change-over produced a new surge of power and brought 50 per cent more listeners within easy hearing distance of the station. . . . Dr. Condon who is now conducting experiments on uranium and other elements with the Westinghouse 90-ton atom smasher made the following comment on the splitting of the uranium atom:

"'An individual uranium atom is like a bomb containing energy ready to explode but not touched off. Thanks to the discovery of uranium fission, we now know how to touch off these atomic bombs so they release all their stored up energy at once. When one of the neutrons is shot into the atom in just the right way, it falls apart in two fragments which rush apart with great energy. In one atomic explosion we get 50,000,000 times as much energy as when an atom of coal is burned. "'If we can learn how to keep the process going by itself, we shall have in uranium a new fuel which gives off about 2,000,000 times as much energy—weight for weight—as coal or oil.

"'It is too soon to be able to say whether uranium will be practical as a fuel. But the work on this process in research laboratories, including our own at Westinghouse, is sure to lead to results of great scientific importance, and it may give us new sources of power.'"

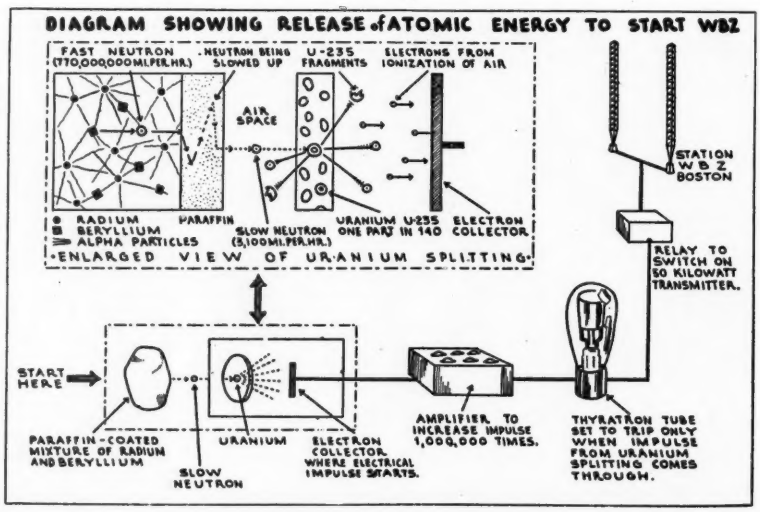
DIAGRAM SHOWING RELEASE of ATOMIC ENERGY TO START WBZ
FAST NEUTRON (170,000,000 MI. PER HR.)
NEUTRON BEING SLOWED UP
U-235 FRAGMENTS
ELECTRONS FROM IONIZATION OF AIR
AIR SPACE
STATION WBZ BOSTON
RADIUM
BERYLLIUM
ALPHA PARTICLES
PARAFFIN
SLOW NEUTRON (5,100 MI. PER HR.)
URANIUM U-235 ONE PART IN 140
ELECTRON COLLECTOR
ENLARGED VIEW OF URANIUM SPLITTING
RELAY TO SWITCH ON 50 KILOWATT TRANSMITTER.
START HERE
PARAFFIN-COATED MIXTURE OF RADIUM AND BERYLLIUM
URANIUM
SLOW NEUTRON
ELECTRON COLLECTOR WHERE ELECTRICAL IMPULSE STARTS.
AMPLIFIER TO INCREASE IMPULSE 1,000,000 TIMES.
THYRATRON TUBE SET TO TRIP ONLY WHEN IMPULSE FROM URANIUM SPLITTING COMES THROUGH.

HOW IT WAS DONE: Neutrons (neutral atomic particles) from a mixture of radium and beryllium are slowed down in passing through a coating of paraffin and strike a small target of uranium about the size of a dime. One ator in 140 of the uranium will be in the form known as U-235. About once in every 10 seconds a slow neutron hits the nusleus, or heart, of a U-235 atom and shatters it into five parts—two new atoms of different elements and three neutrons As these fragments fly apart with an energy of 200,000,000 electron-volts, they ionize (electrify) the air in the apparatus and permit a small electric current to flow through a circuit. Following an amplification of about a million times, the current is strong enough to trip a thyratron tube which in turn operates a relay to switch on the new transmitter.

The PRACTICAL ENGINEER and ELECTRICIAN

ANDREW W. KRAMER, EDITOR

He Puts Vinegar On His Floors

One of the readers of this section informs us of a tough problem concerning his floors. His plant is a large food products company in Chicago and at the present time he is confronted with the problem of developing longer wearing floors in the relish rooms and other rooms where vinegar is handled. "We are using tile floors in these rooms in place of the usual concrete but we find that the grouting between the tile disintegrates rapidly under the action of the vinegar which inevitably finds its way to the floor. Several different chemicals are being used in this grouting, but so far, we have not hit on the right combination yet. If any readers having similar problems have worked out a durable acid-proof grouting for use on floors exposed to acid or vinegar we sure would like to hear about it." How about it, readers, can you help this poor guy?

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A Section of Power Plant Engineering Devoted to
PLANT OPERATION AND MAINTENANCE
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Stopping Boiler Leaks

Have you ever had a leak develop in a boiler that you could not shut down conveniently to make necessary repairs? If so, you will be interested in this description of a method that proved successful and that did not require very much time nor effort.

By D. O. Lima

Testing Engineer, Generation Department
Oklahoma Gas & Electric Company

IN 1939 two Heine 516 hp 165 psi boilers in a small stand-by power plant were found leaking at the fire ends of many of the box header staybolts. The boilers had been retubed the year before to make them dependable in case they were needed, the plant being at the far end of a transmission system where it was necessary to maintain standby power supply. Since it would be impossible to calk the fire ends of the staybolts without another retubing, consideration was given to other possible means of stopping the leaks, if only temporarily.

A very dilute solution of sodium silicate, or water glass, was known to be effective in sealing small low pressure leaks providing the vessel which leaked was kept hot and well aired so as to permit the solution which seeped out to evaporate completely at the point of leakage and thereby concentrate the silicate to a solid deposit which would finally seal up the leak. It was not known whether leaks under moderate pressure could be sealed in the same way, but it was thought worth trying as the cost would be small. However, many of the leaks in these boilers were not just seeps, and it was thought advisable to add some other material which would lodge in and plug the larger leaks from the inside and thereby reduce the rate of leakage to a point where complete evaporation of the escaping water could take place and allow the silicate to do the sealing. It was decided to use fine cottonwood sawdust and linseed meal for this purpose. The sawdust was obtained from a box factory. A fourth ingredient, blackstrap molasses obtained at a feed store, was added for good measure, because on heating it leaves a char which is not water soluble.

The boilers hold about 5000 gallons each and the quantities of material used were as follows:

O-Brand sodium silicate	55 gal.
Molasses	55 gal.
Fine sawdust	50 lbs.
Linseed meal	50 lbs.

The sodium silicate and sawdust were thoroughly mixed in a steel drum, and then about 20 per cent by volume of water stirred in for the purpose of increasing the fluidity of the mixture. This was poured into the boiler drum after first having heated the boiler up to about 200 F. The linseed meal was worked into a thin slurry with water and poured in the drum, and the molasses was poured in without dilution.

The boiler was then closed and fired rapidly to popping pressure. This was conveniently done since the fuel is natural gas. While firing up, the boiler was vented so as to produce some boiling and circulation and prevent segregation of the ingredients. The boiler was fired at about full rating for half an hour, the steam escaping through the safety valves. The burners were turned off and in a couple hours the furnace was cool enough to permit a hasty examination. No leaks could be seen or heard. The following morning the boiler still had a little pressure, and a more careful inspection indicated that all the staybolt leaks were stopped. The same procedure was then repeated with the other boiler.

The boilers were then kept banked with 5 to 10 lb pressure for an additional 24 hours in order to be more certain of complete sealing of the leaks. After the boilers had cooled off a drum manhead was removed to determine whether the sawdust and linseed meal might be floating on the surface of the water, but this was found not to be the case.

Results

The treatment of the boilers was carried out on May 10th and 11th, 1939. On May 16th one staybolt in one of the boilers leaked slightly under full pressure. On July 29th there was no evidence of leakage in either boiler. All the material was still in the boilers and caused considerable carryover when the plant was operated. Heavy blowdown corrected this.

In June, 1940, about a year later, 4 staybolts were found leaking in No. 1 boiler. The boiler was steamed half an hour with 25 gallons of sodium silicate added. This stopped 3 of the leaks. Twenty-five lbs of linseed meal were then added and the boiler again steamed, which stopped the fourth leak. Since that time the boilers have remained leak-free or very nearly so. At the present time without any further treatment there are 3 or 4 small leaks in No. 1 boiler and one in No. 2.

Conclusions

Small leaks below the water line in low pressure boilers can be stopped by adding 5 gal. sodium silicate (SiO_2/Na_2O ratio of about 3.2), 5 gal. blackstrap molasses, 5 lb each of fine sawdust and linseed meal for each 1000 gal of water the boiler holds, firing the boiler and allowing it to steam vigorously. The material cost, exclusive of fuel, for such treatment is between $2.25 and $2.50 per 1000 gal of water capacity based on 1939 prices. Possibly equally good results could be obtained by eliminating the molasses and using smaller quantities of the other materials. The molasses is suspected of being a strong foaming agent.

While such treatment is not to be recommended indiscriminately, there is recent evidence that sodium silicate is an effective sealer of small leaks even in boilers operating in the 1200-1400 lb range. In one case reported in "Combustion," Vol. 16, No. 6, p. 37, the removal of sodium silicate deposits within the boilers by substituting potassium salts for the sodium salts in the boiler water developed numerous hand-hole cap leaks.

Concentration Control and Boiler Trouble

By Charles W. Parks

ABOUT A YEAR AGO I wrote an item in the PPE stating that five of our cast iron sectional headers of one of our boilers had burst. Not long after this, two broke on No. 3 boiler and shortly afterward another one broke. At the time of the incident, we were unable to advance with an idea as to what was the cause other than crystallization due to old age.

We now have the problem practically solved and I am passing it along to whom it may concern. During repairs to No. 3 boiler the last time, we discovered that the mud drum was divided into two parts by a partition. This leaves two blow-down openings on one side and one on the other. At this time we were only blowing down one valve in 24 hours for sludge removal. The concentration was controlled by the continuous blows. The continuous blow down was controlled by the chlorides determination. Our schedule called for no change in blow down between 150 and 200 parts per million of chlorides. We were experiencing some foaming trouble at this time. By checking up we found that the chlorides followed very closely to concentration in grains per gallon,

which meant that our concentration could travel from 2565 to 3420 parts per million without any change being made in the blow down. By further checking we found that we should maintain a concentration of from 2200 to 2700 ppm which only allowed a range of 500 ppm.

In an effort to correct the trouble we first bought an electric meter for an accurate determination of concentration at any time. We worked out a system of blowing down by blowing all valves every 24 hours regardless of the concentration and blowing any excess concentration by use of the continuous blow-down. This practice has been in effect for nearly a year and no broken headers have been experienced since and the foaming stopped about two weeks after we started this system. I have now come to the conclusion that there was compound building up in the mud drum and causing foaming, which at some critical moment caused a sudden change in temperature that caused a sudden expansion thereby bursting the headers. I have also come to the conclusion that concentrations should not be controlled by the chlorides determination. If it is necessary to do so, make a chart of concentration in parts ppm by multiplying the grains per gallon by 17.1 and comparing the chlorides by it and blowing down accordingly. The concentration limit for your boiler should also be previously found.

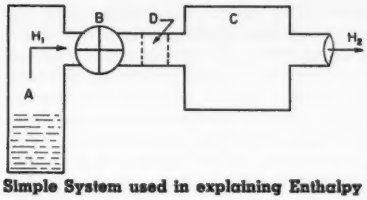
The Meaning and Use of Enthalpy

Tyler G. Hicks

READERS of technical articles dealing with power generation and application are familiar with the word enthalpy. It may be recalled that the author of such an article generally fails to define enthalpy. Instead he says that the word means the same as the more familiar term "total heat." Because the last statement is erroneous the word enthalpy will herein be defined. The relation between enthalpy and total heat will also be discussed.

For the sake of analysis imagine a simple steam plant such as that shown in the accompanying diagram. It consists of a boiler A, stop valve B, and a "steam consuming" device, C. This last piece of apparatus might be an engine, turbine, injector or nozzle.

It is a well-known fact that before steam can be generated from water enough heat must be added to allow molecules to break away from the water. Stated another way, the velocity of water molecules must be increased until it reaches the velocity of steam molecules before steam will be formed. To bring about this change, energy in the form of heat must be added to the water. The energy added to the water is generally called the internal energy, E. It is the energy stored in a substance by virtue of the increased velocity of the molecules.



Simple System used in explaining Enthalpy

Suppose now that heat is applied to the boiler, A and that steam is generated at atmospheric pressure, 14.7 psia. Valve B is opened and steam allowed to flow through device C. A condition of steady flow will be assumed to exist. This means that if the boiler generates one pound of steam per unit time, one pound is exhausted from the device during the same time interval.

Imagine one pound of this fluid in the pipe, such as at D. In order to push this mass through the pipe a force will have to be applied at one end of the mass. This force is equal to the pressure, P, lb/sq ft, of the fluid in the pipe multiplied by the area, A sq ft, or the pipe, or

$$\text{Force} = PA$$

The distance this force must travel in order to force one pound of the fluid into C is,

$$\frac{\text{Volume of one lb, cu ft}}{\text{Area of pipe, sq ft}}$$

Therefore, since work = force × distance,

Work to push one lb of fluid into

$$C = F \times d = PA \times \frac{V}{A} = PV \text{ ft lb.}$$

Assuming that the internal energy, E, of the stream is known, enthalpy may be defined as follows,

$$\text{Enthalpy, Btu} = H = E + \frac{PV}{J}$$

$$J = 778 \text{ ft lb/Btu}$$

Thus it is seen that the total energy of the steam entering this system is equal to the internal energy plus the term $\frac{PV}{J}$, sometimes called the flow work. In the simple system shown, the quantity of energy would be: $Q_{in} = H_1 - H_2$, assuming that no work is done.

My name's Jones all right, but it must be for that Jones over there!

In the above case the "total heat" added equalled the enthalpy change. However, this is only a special case. Ordinarily heat is lost from the prime mover in the form of radiation and work is done by the machine. The quantity of energy added, Qim, would not equal H_1—H_2, but the expression would be more involved.

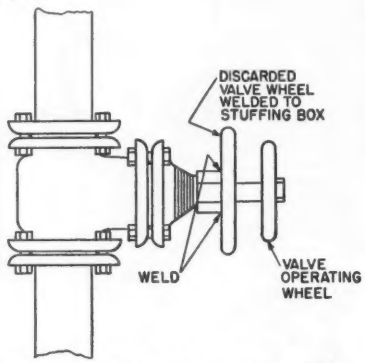
In all the latest steam tables the term enthalpy has been substituted for "total heat." Enthalpy changes are used in computing the work done during certain thermodynamic processes, heat released by the condensation of steam, and in all other computations where the older term was used. Strictly speaking enthalpy is the better term to use because it not only conveys the correct meaning but also helps to keep the concept of flow work in mind.

PRACTICAL HINTS AND KINKS

Ammonia Valves

THE STUFFING boxes of valves used on ammonia lines must be kept tight to prevent the escape of the gas. Therefore, whenever a valve is opened or closed the stuffing box must first be slackened so the valve wheel can be turned, then tightened again afterward. The stuffing box is usually loosened and tightened with a wrench.

To eliminate the necessity of using a wrench, and the consequent danger of its slipping and causing injury to the user or the equipment, a valve wheel can be welded to the stuffing box, as shown in the accompanying sketch, so that it may be slackened and loosened simply by turning the wheel.



Showing how Valve Wheel can be welded to stuffing box.

A wheel from a discarded valve may be used. The wheel should be larger than the valve operating wheel, both to provide sufficient leverage to tighten the stuffing box and to enable a large enough hole to be drilled through the center or hub so that it will easily pass over the valve stem. The stuffing box should be removed from the valve for welding and care should be exercised to avoid damaging it by heat.

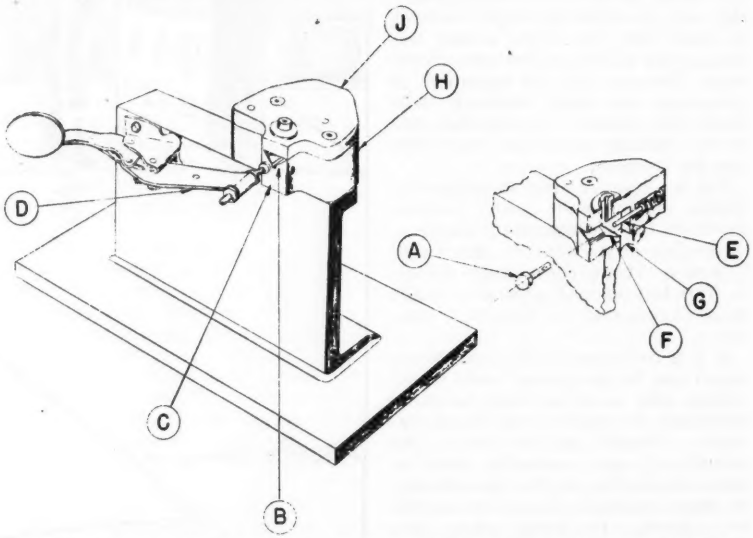
Valves altered in this manner are especially convenient on compressor manifolds and expansion lines to evaporators where frequent operation of the valves is required.

Self-Ejecting Drill Jig

A SELF-EJECTING drill jig has been designed and developed by Leo Malecki of the Tool Design Section at General Electric's Schenectady Works. Besides combining both simplicity and economy in design, it is very effective in increasing production and reducing drill breakage.

The part being drilled is placed in the jig, and the underside of the head of this part is located and clamped against the surface. Having been depressed by the clamping action, the springloaded pin ejects the machined part from the jig when unclamped.

The chamfer and hole in the channel in the V-block of the jig provide for the removal of chips. A fabrication of a channel and base plate is the support for the V-block and bushing plate. The base plate is of sufficient size to allow the clamping of the drill jig with the drill bushing positioned under the spindle of the drill press.



Drawing showing various sections of self-ejecting drill jig: A—part to be machined, B—jig, C—surface, D—clamp, E—spring-loaded pin, F—chamfer, G—hole in channel, H—V-block, J—bushing plate.

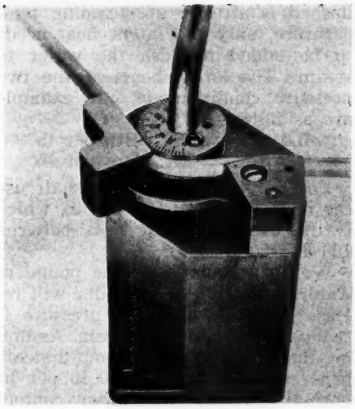
Bending Small Tubing

A NEW HAND-BENDING TOOL, which permits all kinds of small tubing to be curved to any desired angle, has been developed at the Glenn L. Martin Co., Baltimore, Maryland.

Designed by a Martin employee, Carroll E. Adreon, the new tool consists of a sturdy steel base which may be used in a vise or clamped onto a bench; a revolving radius rod equipped with a handle for turning; a stop block grooved to hold the tubing; and a movable radius block which guides the tubing around a bend roll centered on top the base. This roll, cylindrical in shape and also grooved, has a top plate scribed in 360 deg. A measuring point is marked on the movable radius block. The radius and holding blocks and the roll are so grooved as to prevent crushing or change in section of the tubing.

In operation the tubing is inserted in the groove of the stop block and the movable block which has been returned to the zero degree point. The movable block is then pulled around the bend roll, being connected to the revolving radius rod, until the measuring point is directly opposite the mark of the angle desired in the bend roll.

Allowances can be made for tubing having a "spring back" characteristic by merely moving the measuring point to as many degrees beyond the desired angle marking as the tube will spring back when released. An operator can easily measure this amount of allowance needed from the spring back shown on the top plate of the bend roll, when pressure on the handle is released. Utilizing the same principle, tools may be made for bending tubing of any size.



By the simple substitution of a set of phenol fibre blocks, similar in design to the metal blocks, hot-dipped or tinned spiral high-electrical cables (for example, battery cables) also can be bent in the new tool. Use of the phenol fibre accessories prevent the semi-molten coating on the wire from adhering to the blocks, as would be the case with use of the steel blocks on the original tool.

Chief advantages of the new device lie in the great amount of time saved as compared to ordinary hand bending operations, the extreme accuracy to which the tubing can be turned and a material serving in that there is no scrap due to the tubing being crushed or split during the operation.

Boiler Room Operating Hints

By C. L. SHOBE

A leak developed in a ½-in. nipple leading from the water column on one of our 120-hp Sterling Boilers to the feedwater control element. The leak promised to get bad and could not be shut off.

The boiler was filled to capacity with water (until the high water alarm sounded) after the fire had been extiguished. The heat had been turned on in all the buildings and vacuum pump left running (this pump is electric). In 20 minutes time the radiators in the buildings had pulled the steam pressure down to zero, the connections which were leaking were removed and we found that the vacuum pump was pulling air into the boiler besides taking out the steam being generated by the hot setting. The repair was made and the fire started in 45 minutes from the time it went out. We think this was a much better way to make a quick repair than pumping water into the boiler and blowing it down. The radiators had more capacity for condensing steam than the hot setting had for generating steam. The electric vacuum pump kept air going into the opening while the repair was being made.

We have found that blowing the water glass on the water column for long periods wears it thin and that it is necessary to blow it for only a short period. We blow the water column until hot water and steam are drawn clear through from the boiler drum. This takes about ½ minute. Shut it off, opening the valve blowing the glass down as the water column valve is being closed. By the time the valve on the water glass blowdown line is open, it has blown enough and is immediately closed. By blowing the column first, it is cleaned out. There is not much capacity for water and dirt in the glass and fittings so that very little blowing is necessary to change the water in those. We have been getting triple life from our gage glasses since following the above procedure.

Although the water should rise and fall slightly in any boiler to distribute water line erosion, we find that a small plant which has a load varying from full to nothing should have a sensitive feedwater control, especially if the fire is turned out or the steam consumption is stopped the water falls, the control admits more water to raise the level to normal which prevents popping and waste of steam so frequently.

There has been some argument against home made feedwater controls. We have one that has operated successfully for seven years. We are using 6 by 4 by 6 in. steam pumps, for boiler feed, and are equipped with bronze rods. The cost of new rods are $8.95 each and last 1½ years on the water end, 3 years on the steam end. We were able to get them built up and turned down on one end for $3.00 each, both ends for $5.00 each, and found to give the same service. We later found out that type M government copper, size 1 in. and hard drawn was the same diameter as the rods outside. Now we are turning the rods off and sweating a sleeve of the copper pipe in place and find that it gives about ½ the service of new or built up rods. The rods are 1⅛ in. and turned down to 1 in. a hole is drilled (⅛ in.) in solder. It so happened that we had a full length of this copper on hand when the restrictions went on, so we were fixed with rods for the duration. The cost of a complete replacement is less than $2.00. We use a regular steam packing on the steam end and a much softer packing on the water end.

We are using Rock hard solid ring packing in all pumps either hot or cold water on the pistons with a new piston and liner we get 1½ years of service without any attention (this is continuous operation and brass liners). When they loosen up in the liner the rings are removed and pounded lying flatways on an anvil. While soaked they can be expanded an eighth of an inch or more. They remain a snug fit in the liner for quite a period and the pounding can be repeated several times. Pounding expands the ring larger than the piston but as the bucket plate is lightened up against the rings it makes no difference.

We did at one time use grease and graphite on our manhole gaskets. Corrosion had started around the face and seat of the plate. Now we use red lead powder and red engine oil on the plate and gasket. After three years it has been found satisfactory. The two are mixed to a thin paste.

We are using a pipe dope of overaged aluminum paste mixed with red engine oil for pipe of all service hot and cold water, steam, etc.

The paste must be used that has not had any bronzing liquid added, otherwise, it will not mix with the engine oil but will form a curdle and gummy mass. The unused paste mixed with red engine oil forms a smooth lubricant and filler, which will stand heat, is easy to wipe off of pipe and hands, holds well, and never dries out in the can.

Can be applied sparingly to one side of the threads, and will distribute evenly as the pipe is turned in. It makes a beautiful job of an installation of galvanized pipe as it is the same color as the pipe and the joints do not show up after wiping. We use a small acid brush for application.

We have found that a good grade of soldering paste can be used as a lubricant on valve stems, regulator stems, etc., carrying steam or hot water as it will stand up under considerable heat.

Our best formula for patching outside of boiler settings is a mixture of half and half lime and cement (no sand or other material) mixed with water to a sloppy muddy mass and applied with a brush or trowel. The best time to apply is when the fire is first put under the boiler, and while the setting is still cold and there is draft to aid in pulling it into cracks and openings. Another application should be made with the setting heated and fully expanded. A hot setting dries the mixture before it can be forced into the openings.

How to Calculate the Accumulator Capacity of a Boiler

As a result of the publication of the author's article on The Harbor Steam Plant Boiler in the June, 1945, issue of POWER PLANT ENGINEERING, he has received many inquiries about the problems involved in having a boiler act momentarily as a steam accumulator and in calculating the accumulator effect. Here is how he has explained these points to the inquirers

By MAX H. KUHNER

Chief Mechanical Engineer
Riley Stoker Corporation

TO DETERMINE the accumulator effect of a boiler, there may be formulas in handbooks to give the answer, but I always consider it more advantageous to analyze a problem without being influenced by preestablished formula.

A boiler can be operated to act as an accumulator whenever the nature of the steam load makes it desirable. Certain industrial processes demand highly fluctuating steam flow. I recollect one industrial plant where the steam flow from the boiler is such that the flow meter pen travels between 20 per cent and 100 per cent of design load in 2-minute cycles, 24 hr per day. Naturally it is impossible for the firing rate to follow the rapid and extreme fluctuations of the steam output. So the burners are adjusted for a constant firing rate and the boiler pressure is permitted to rise and fall with the steam demand.

Where sudden increases in steam demand take place, the boiler is invariably called upon to act momentarily as an accumulator because it is in most cases physically impossible to liberate heat in the furnace at the same time and at the same rate as the steam delivered by the boiler. The Harbor Steam Plant boiler discussed in the June issue of POWER PLANT ENGINEERING is an example.

Another case in which a boiler acts as an accumulator may be while fuel firing is temporarily interrupted; as, for instance, to change from one type of fuel to another, or to change oil burner guns. The boiler is then called upon to deliver steam with gradual drop in pressure while no heat is delivered to the boiler.

It is not difficult to determine what the accumulator capacity of a boiler may be. The water content of the boiler below the working level must be known and it is, of course, necessary to establish maximum permissible loss in steam pressure. The steam delivered by the boiler during the period in which no heat is liberated in the furnace is generated from heat stored in the boiler water. This heat is made available by the drop in pressure. The greater the permissible pressure loss, the more heat is made available for the generation of steam. Also, the greater the weight of water contained in the boiler, the greater is the amount of heat stored and therefore the lower is the pressure loss for a given quantity of steam flashed from this boiler water.

The steam tables show the heat contained in water at various pressures and corresponding steaming temperatures. The higher the pressure the more heat is stored in the water. As the pressure is reduced to a lower point, the difference between the heat content at the original high pressure water and that at the lower pressure is released in the form of flashed steam.

Analysis of a 700 psi, 200,000-lb-per-hr Boiler

If we take, for example, a boiler normally operating at 700 psig drum pressure and let the pressure drop to 500 psig by shutting off all source of heat in the furnace, the change in the condition of the water in the boiler will give us the following:

Heat of liquid, boiler water 700 psig, 505 F = 494.4 Btu per lb
Heat of liquid, boiler water 500 psig, 470 F = 453.0 Btu per lb

41.4 Btu per lb = available heat to flash into steam.

The heat contained in saturated steam consists of two distinct parts. The first part is the heat required to bring the water up to steaming temperature (heat of saturated liquid), and the second part is the heat required to transform the liquid to vapor (latent heat). Because the boiler water from which the steam is flashed is already at steaming temperature, only the latent heat needs to be added to flash the water to steam. The latent heats at the two pressure conditions of our example are as follows:

700 psig = 706.5 Btu per lb
500 psig = 751.3 Btu per lb

For our calculations we shall use the mean, or 728.9 Btu per lb, which is the average latent heat between 700 and 500 psig.

We have found that one pound of water contained in the boiler will release 41.4 Btu when its pressure is reduced from 700 to 500 psig. Assuming that we are talking about a steam generating unit of 200,000 lb per hr normal capacity, the water content below the normal working level of this unit will be about 1800 cu ft. At 700 lb pressure, 1 cu ft of water weighs 48.6 lb so that there are 87,500 lb of water contained in this boiler while the boiler is operating at 700 lb pressure.

The total heat released while the pressure is permitted to drop to 500 psig is then 87,500 x 41.4 = 3,620,000 Btu and the steam flashed is 3,620,000 ÷ 728.9 = 4,970 lb.

A steaming rate of 200,000 per hr is 55.6 lb per second. If this rate is maintained, the pressure drop from 700 to 500 psig will take place in 4970 ÷ 55.6 = 89 seconds.

In other words, the steaming rate of 200,000 lb per hr could be maintained only for about 1½ minutes before the pressure in the boiler dropped to 500 lb.

With these calculations it is, of course, assumed that there is no heat whatsoever given off to the boiler water. However, boiler installations are enclosed in brick walls or have refractory furnaces and a certain amount of heat is of course radiated from refractory walls and conducted from baffle walls into the boiler tubes. This will help to somewhat prolong the steaming rate while fuel burning is interrupted. Even boiler units with completely water-cooled walls are not as critical as the above theoretical calculation indicates. Some of the heat stored in the metal of tubes, drums and headers is made available during drop of pressure and will assist steam formation.

It is desirable to prevent colder feedwater from entering the boiler while the boiler is performing as an accumulator. If the feedwater regulator is controlled solely by water level, the feedwater flow is automatically interrupted simply by the "swell" of steam forming under water, and the resulting water level rise.

In our example, 4970 lb of water is flashed into steam and removed from the boiler in 89 seconds. If the main steam drum of the boiler is 60 in. I. D. and 22 ft long and if the original working level was at the center of the drum, the water level will finally have dropped approximately 12 in., that is, the final water

level in the drum will be 12 in. lower, but the lower water level will only be apparent at the end of steam flow.

Restoration of Pressure

One thing must not be forgotten: that a large quantity of heat is removed from the boiler water during accumulator operation and that this heat must be restored while the operating pressure is being brought back to the original point. It is necessary, therefore, to burn more fuel during the period of restoring pressure than the fuel required to generate steam. I mention this fact because it affects the selection of mechanical - draft equipment and fuel-burning equipment. If it is desired to keep the steam output rate at maximum while at the same time the pressure is being brought back to the original point, fuel-burning equipment and fans must be of greater capacity than if they were just proportioned to a continuous maximum steam output capacity.

If, for example, it should be necessary to restore the full pressure of 700 psig in our boiler in 1.5 minutes while it is delivering steam at the rate of 200,000 lb per hr at the same time, the firing rate would have to be just about twice that required to generate the full steam output at 700 psig. Fans and fuel burning equipment of modern steam generating units have usually 15 per cent or more leeway over and above the capacities needed for maximum steam output for which the units are designed. If we assume 15 per cent and if fans and fuel burning equipment are running at maximum capacity, 10 minutes are required to restore full pressure under the conditions of our example.

But fans and fuel burning equipment may not be the only limitation for rapid build-up of pressure. Where a high-temperature superheater is installed, the rise in steam temperature caused by accelerated firing may control the time required. It must be realized that more heat is applied to the superheater during this period. With constant steam flow through the superheater but greatly increased heat input, the steam temperature may reach dangerous limits!

The Story of the Steam Gage That Failed to Register

By Sam J. Ayling

ONE OF THE boilers in our plant had been off the line for the regular cleaning and inspection. When the inspection had been completed the operating engineer in charge started a fire under the boiler and proceeded to get up steam. After a period of about two hours the operating engineer became alarmed. The reason for his alarm was that the steam gage on the boiler failed to register pressure. After a hurried inspection the oil was turned off and a thorough check-up made without disclosing anything wrong, however. That same night the boiler was taken off the line.

The next day many suggestions were made as to what might be wrong with the gage; it was evident that there was nothing wrong with the boiler.

So the steam gage was taken off and connected to one of the air compressors and under 20 lb. pressure still the pointer failed to move.

Now for the $64 question. What do you suppose was wrong with the gage?

Well, here is the story behind this unruly gage that failed to register with 20 lb. pressure applied to it. The engineer on the night shift had removed the gage in order to clean the inside of the glass. During this operation the waste he was using came in contact with the steam gage pointer, lifting the pointer to the opposite side of the pin. Several men looked the gage over but none of them had anything to suggest. Finally, however, we heard the boilermaker laugh and at the same time heard him say, "no wonder the pointer will not move; it is on the wrong side of the pin."

There were many red faces in the boiler room after the trouble had been located, and the engineer in charge had many bitter words with the big boss. The engineer contended that the pointer could not get to the left side of the pin without someone lifting it to such a position.

The big boss said he thought it could. Finally the engineer who had cleaned the gage confessed that he was the one responsible for the pointer being on the wrong side of the pin.

To many this account may seem incredible, nevertheless it is all true. And the moral of this story, perhaps, is the old saying, "It can happen here, there, or anywhere."

Use of Silver in Sterilizing Water for Burma Road

A REMARKABLE STORY of ingenuity and resource has just been told by S. F. Benton, British scientist in India. This is how essential pure water was supplied to the 30,000 native laborers rushed up to Assam in March, 1942, against the threat of the Japanese advance, to work on the celebrated new Burma Road.

Without pure water the situation, militarily, would have been very grave. Three of the world's most deadly diseases, bacilliary dysentery, cholera and typhoid, are mainly transmitted by polluted water.

The neighboring rivers are all badly polluted by the villages of the local Naga tribes, and dysentery broke out among the laborers as soon as they reached the construction site. Moreover, cholera was already prevalent among the Nagas, and the medical officer with the laborers warned that if sterile water supplies were not available before the opening of the cholera season with the early rains of mid-April, half the labor force might be lost, and the Manipur Road closed.

Obviously pure drinking water daily for 30,000 men could not be provided by boiling, and filtration on the scale required was impracticable and not sufficiently reliable. Moreover, since the laborers greatly dislike the taste of chlorinated water, it was probable even if chlorinated water were provided, they would still have preferred to drink the polluted stream water.

Hence, a fourth method, only just emerged from the research stage, was adopted. It involved treating the water electrolytically with silver. One part of silver in 100 million parts of water will effectively kill all bacteria. Exactly how it works is unknown, but it is believed the silver replaces some other metal in the water, essential for the breathing of the bacterial cell.

All that is necessary for sterilizing water in this new way is a small direct current and two silver plates. A current flow of only 10 milliamps is sufficient to treat 1,000 gallons of water an hour. At the start the only source of current Mr. Bention had was 4.5 volt flashlight batteries, and the complete stock, 125, in the little village of Jorhat, was bought up. Four batteries were connected up and placed on a piece of wood which was floated on top of the water in the tarpaulin tank. The batteries were wired to two small silver plates 4 inches square, projecting under the wood into the water.

Twenty minutes of this electrolytic treatment sterilized the 3,000 gallons in the tarpaulin tank, and a set of four batteries was capable of sterilizing 36,000 gallons of water a day. By mid-April, there was a daily total output of 100,000 gallons of sterile water. So far from dysentery increasing, it actually decreased.

When the stock of batteries had fallen to two, 50 car batteries arrived from Calcutta. The floating sets were converted to these by using a flex, kept taut to the floating wood with its silver plates by a bamboo used like a fishing rod.

The final stage in this remarkable story is the devising of automatic sets to sterilize water. As the water was pumped into the tank, the stream from the pump completed the circuit, so that when the water stopped flowing, the circuit was automatically broken.

Betz Indicator, from "Science on the March" Section, Scientific Monthly—pub. by The American Association for the Advancement of Science, Washington, D. C., Vol. LX—No. 5, page 395 (May, 1945).

The Boiler Fireman's Handbook

BY J. R. DARNELL

Principles of mechanical atomization . . . Comparative merits of mechanical burners . . . Types of mechanical oil burners . . . Operating Instructions . . . Use of extra burners to maintain high efficiency . . . Grades of fuel oil used in industrial power practice.

Part XVIII Oil Firing Methods (Cont'd) Mechanical Atomization

IN CHAPTER XVII we discussed the relative merits of steam and mechanical atomization and concluded that for the small or medium sized boiler, where the combustion space is ample, that steam atomization gave somewhat better combustion efficiency. Mechanical atomization, however, is preferable where it is necessary to save feedwater, where combustion space is limited and the lighter, sludge free oils can be used. Data collected from various sources appear to indicate that if relatively light oil, free from sludge is supplied at high pressure and temperature, mechanical burners will produce finer atomization than steam burners. Finer atomization if the air is properly mixed, means a shorter, more concentrated flame and consequently less combustion space required. Space does not permit discussion of the proper design of refractory for the air throat in which the burner is centered, the proper combustion space, the merits or demerits of ignition arches nor the effect of preheated air.

One important advantage of the mechanical burner over the steam atomizing type is the fact that the former can be installed in two rows, the air for combustion being admitted through the register of the burner while the latter are installed in a single row because of the manner of air admission and the character of the flame. In Fig. 1 showing one of the boilers in an industrial plant, there are two mechanical burners in the lower row with one burner above. These burners operate with forced draft. Figure 2 shows a cross-sectional elevation of a mechanical burner designed for forced draft.

In Fig. 3 is shown a design of mechanical atomizing oil burner arranged for operation with natural

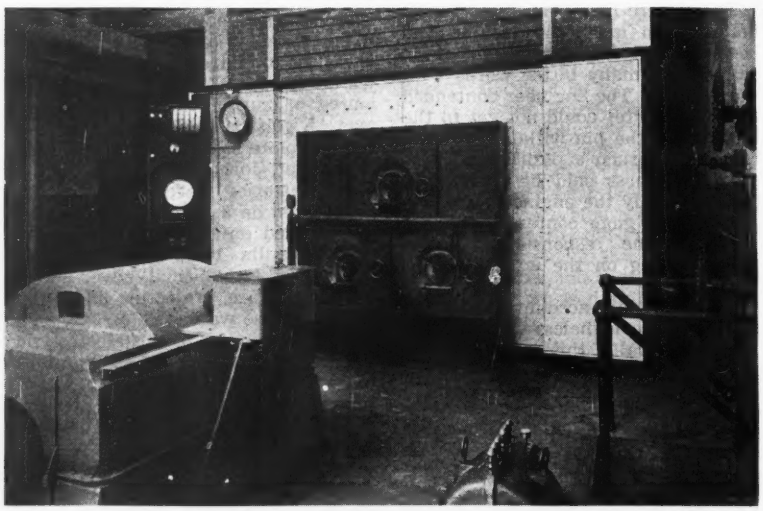


Fig. 1. These oil burners with mechanical atomization and forced draft are installed in a small industrial plant

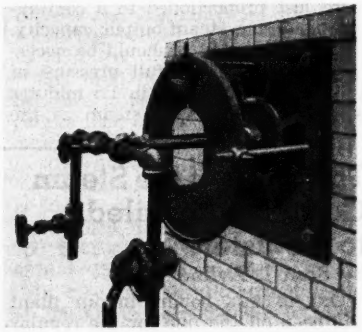


Fig. 4. A simpler type of air register than shown in Figs. 2 and 3 is made in single casting with stationary vanes and may be used with either steam or mechanical atomization

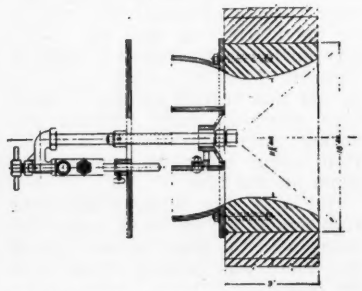


Fig. 5. This is a sectional elevation of the air register shown in Fig. 4, with mechanical atomization

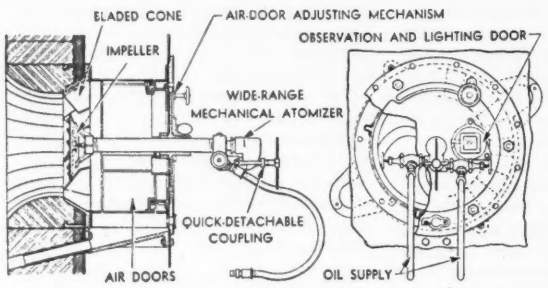


Fig. 2. Air turbulence in this mechanical oil burner designed for forced draft is effected with both stationary and movable vanes

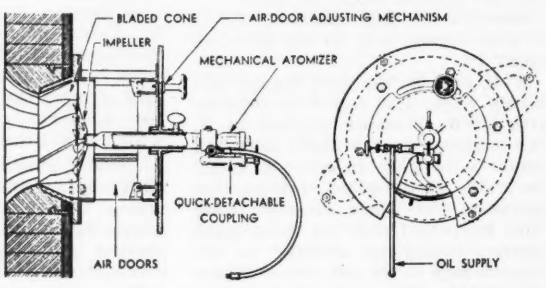


Fig. 3. This mechanical burner with the same means for air trubulence as in Fig. 2 is designed for natural draft

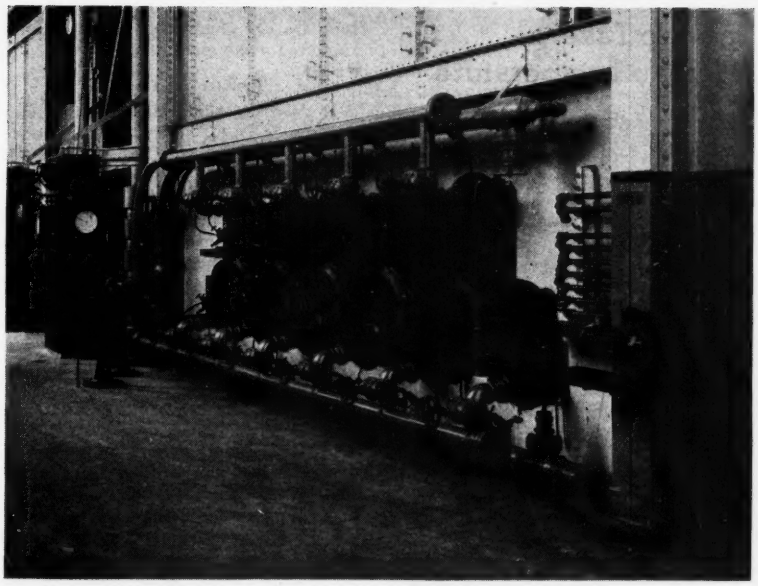


Fig. 6. These two rows of mechanical burners are designed for burning either fuel oil or gas or both

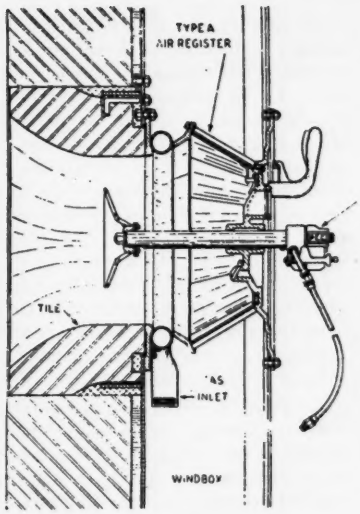


Fig. 7. A sectional elevation of the burners in Fig. 6 is shown here

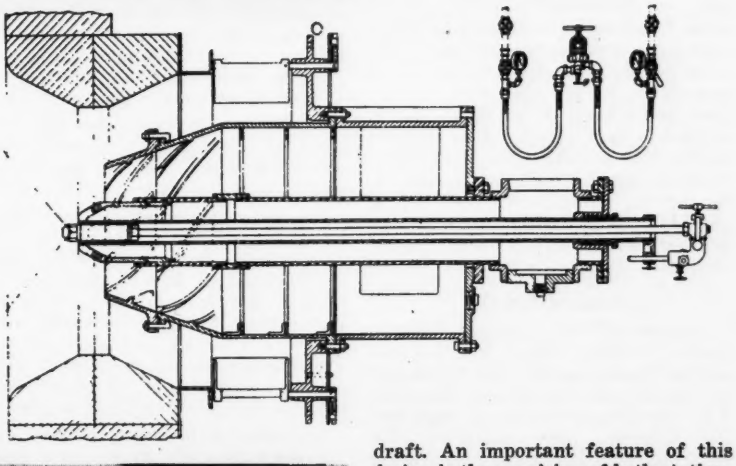


Fig. 9. A sectional elevation of a burner similar to that in Fig. 8 is shown here

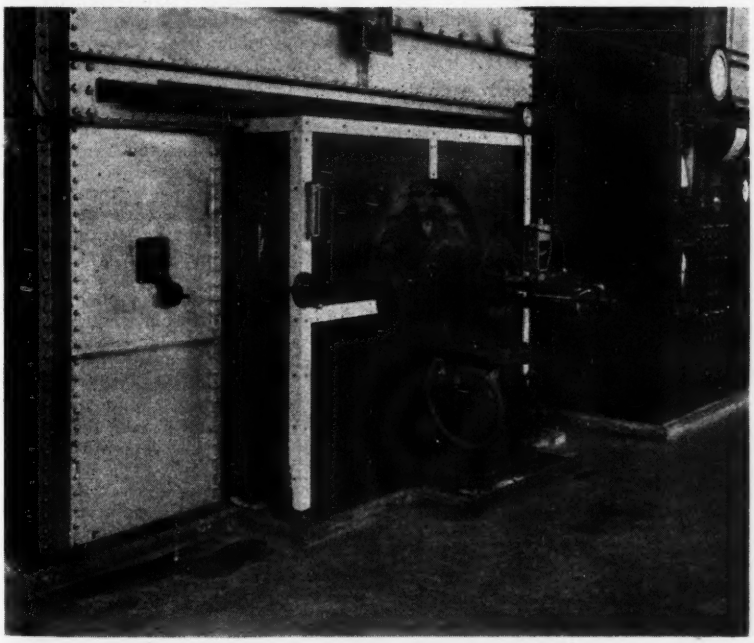


Fig. 8. This small boiler has a combination burner arranged for burning either fuel oil by mechanical atomization or powdered coal

draft. An important feature of this design is the provision of both stationary and movable air vanes to produce turbulence. In Fig. 4 is shown a simpler type of air register made in a single casting with stationary vanes. This register may be used either for a steam atomizing burner as illustrated in Fig. 4 or for mechanical atomization as shown by Fig. 5.

Combustion Burners

Manufacturers of mechanical burners now offer designs which may be used for burning oil, gas, or powdered coal or for combinations of two or more of these fuels. Figure 6 shows two rows of combination burners for oil and gas while Fig. 7 is a sectional elevation of one of these burners.

In Fig. 8 a small boiler in an industrial plant is equipped with a combination burner for oil and powdered coal. Figure 9 shows a cross-sectional elevation of a burner of somewhat similar type.

Operating Instructions

Before lighting the burners, the fireman should be sure that all strainers are clean, then start the pump and

recirculate the oil until it reaches the proper temperature. Then place a lighted torch under the burner and open the oil valve. The oil pressure should be not less than 50 lb when starting and should be gradually increased to 150 lb or over. There should be no flame impingement on any surface as this will soon cause carbon deposit and emit smoke. Air should be so regulated that the flame is yellowish white. A pure white flame which permits observation of the rear walls with the aid of a blue glass indicates excess air. A dark, hazy red flame is indicative of insufficient air.

All mechanical burners are supplied with tips having orifices of varying diameters depending on the amount of oil to be burned per hour and the pressure carried. The possibilities for varying the size of the tips and the pressure of the oil make the mechanical atomizing burner much more flexible than the steam burner. Furthermore, mechanical burners provided with clean tips can be replaced much more readily than steam burners. The operation can be completed in less than one minute. Firemen should be careful to have several extra burners available with clean tips so that if the flame is burning only on one side or is showing streaks of black oil it should be immediately removed and another burner with a clean tip installed.

Grades of Fuel Oil

Commercial fuel is supplied in six grades of which Numbers 1, 2 and 3 are distillates and 4, 5 and 6 residual oils. Most power plants use either No. 5 or No. 6 fuel oil. Firemen may find the following table convenient for checking the temperature required for the grade of oil being used:

Degrees Baume'	Specific Gravity	Temp. °F
10-12	1.00- .986	300-280
12-14	.986- .972	280-260
14-16	.972- .959	260-230
16-18	.959- .946	230-200
18-20	.946- .933	200-170
20-24	.933- .909	170-160
24-28	.909- .886	160-150
28-30	.886- .875	150-140

In the above table the relationship between Degrees Baume' and Specific Gravity may be determined by the formulas:

$$\text{Sp Gr} = \frac{140}{130 + \text{Deg. Be}}$$

$$\text{Deg. Be} = \frac{140}{\text{Sp Gr}} - 130$$

For each 10 degrees above 60 deg. F add 0.7 deg Be and for each 10 degrees F below 60 deg F subtract 0.7 deg Be.

How to Take a Motor's Temperature

THERE ARE TWO methods in general use for taking an electric motor's temperature; these are shown in the accompanying sketch. The technique at the left is easy to recognize because it is all too commonly employed. As an aid to troubleshooting, the maintenance man or operator lays a testing hand to the motor and what he does thereafter is dependent upon the temperature of the motor. In the sketch he is jerking his hand away with the muttered exclamation, "OUCH! That baby's hot." The blistered hand calls for an investigation of operating conditions.

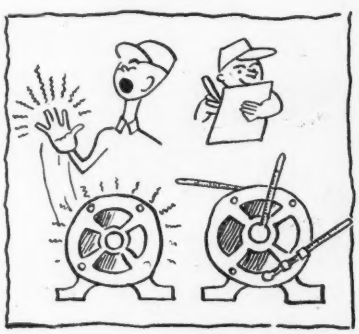
Today, motors are literally "too hot to handle". During the war the War Production Board limitations permitted motors to operate at a temperature of 75 C or 176 degrees F. and today many motors are still operating at such temperatures. With motors operating at such temperatures. With motors operating at 20 per cent overload, this is the temperature they have to operate at and 176 degrees F is much too hot for comfort.

Ruling out the "touch and yell' system for estimating temperature of motors, let's see what the man is doing in our illustration at the right.

He has cemented an ordinary glass bulb thermometer to the stator iron of the motor by means of a felt pad which covers the bulb. As much of the bulb as possible is in contact with the motor part for more accurate temperature reading. Indicated on the drawing are some of the possible locations on motor coil or stator iron where a thermometer might be placed.

Instead of a thermometer, the maintenance man might have used a thermo-couple. The lead would then have been attached to the motor part in the same way as the thermometer bulb.

After correctly affixing the thermometer, the maintenance man has now to calculate the motor's temperature. Since the thermometer reading will always be less than the motor's true temperature, he must add arbitrary factors for correction.



Two methods of determining motor temperature. Left, the touch and yell system; right, the thermometer system.

To Interpret Findings

Let's say that the thermometer reading is 70 C. To this figure the investigator adds 10 C to correct for poor bulb contact, since contact can never be perfect. Now he adds *another* 10 C to the reading. This represents the approximate difference between the temperature of the part tested and the possible temperature of the hottest motor part, or "hot spot" temperature. A total of 90 C, then, is what may be considered as the actual operating temperature of the motor.

Now to decide what this corrected temperature reading means in terms of motor life.

At excessively high temperatures, Class "A" insulation becomes dry and brittle . . . loses years off expected life span. For instance, at a temperature of 100 C, insulation of a motor will have a life expectancy of from 12 to 28 years. If the same motor is operated continuously at 120 C, its insulation will probably fail in 3 to 8 years, neglecting all other factors.

Safe Temperature

A temperature of 105 C has been called "safe" for overloaded motors by NEMA standards. This does not mean that at 105 C as long a life can be expected for the motor as at the normal temperature rise, but it *does* mean that continuous operation of a motor at this temperature will probably not cause breakdown for several years to come.

It's part of the maintenance man's job to help reduce the heat built up in a motor because of added electrical losses, so that overload may be more safely carried.

An overloaded motor should be in an open location, away from barriers, where air can move through the windings and carry heat away from the machine. The motor should be kept *clean*, because presence of dirt and dust will lock the free passage of air from inlet to outlet posts and "insulate" windings, keeping heat inside. Fans mounted on the rotor, which help carry cooling air through the coils, can do their work best when regular motor cleaning is practiced.

When surrounding temperature rises above normal, a forced air stream is sometimes applied to the motor by fans or blower. If this is done, air should be directed into the normal flow channels of the motor—from inlet to outlet vents. Also, air must be clean. If grit, filings or other abrasives are blown into the motor, real damage may be done to the windings.

Non-stop war production schedules are no excuse for lax maintenance. In fact, with replacements nearly impossible to obtain, maintenance has to be *better* than ever before—Allis Chalmers Operation & Maintenance Review.

PROPER CONDUCTORS PREVENT LAMP FLICKER

THE INCREASED use of motors and other electrical devices on industrial circuits as a result of the war has, in some instances, introduced flicker problems. Flicker is not only annoying but it indicates that the conductors are being overloaded and steps should be taken to eliminate it wherever possible.

The Wesco Reporter recently presented a number of tabulations which are of help in solving flicker problems. These four tables, presented herewith, will help you in determining the proper size of secondary conductor when all variables are known. The following factors should be considered:

The values obtained from the tables are valid when primary regulation is sufficient to take care of the starting current.

Since in some cases the method outlined here would require the use of service conductors or transformers of larger size than is usual, some judgment should be used in its application.

When a current limiting starting device is used, the value of the starting current used in the calculations should be the value limited by the starting devices.

Table I—Average Starting Currents of Three-Phase Squirrel-Cage Induction Motors.

Hp.	Volts (Line-to-Line)					
	110	208	220	440	550	2,200
1/8	.....	....	3.7	.....	.....	.....
1/6	.....	....	4.6	.....	.....	.....
1/4	.....	....	6.4	.....	.....	.....
1/3	.....	....	9.6	.....	.....	.....
1/2	19	....	10	4.8	3.8	.....
3/4	29	....	15	7.1	5.7	.....
1	41	....	21	10	7.9	.....
1½	58	....	31	15	13	.....
2	72	....	38	18	15	.....
3	105	57	52	25	20	.....
5	165	88	82	41	36	.....
7½	235	115	120	57	46	.....
10	300	155	150	74	59	.....
15	415	225	220	105	84	.....
20	490	285	275	130	105	.....
25	660	360	355	165	135	.....
30	775	410	415	190	155	40
40	1,110	530	555	275	220	55
50	1,370	715	690	345	290	68
60	1,650	....	865	410	340	95
75	2,010	....	1,050	500	395	110
100	2,940	....	1,500	735	590	150
125	3,380	....	1,800	845	675	195
150	4,610	....	2,390	1,155	920	255
200	6,580	....	3,290	1,635	1,320	295
250	7,300	....	3,650	1,825	1,460	365
300	.....	....	.....	.....	.....	475

Use of the Charts

Following information is required before the secondary conductor size can be determined from the charts:

1. Number of starts per hour, minute or second of the motor.

2. Make and size of distribution transformer to be used.

Table II—Average Starting Currents of Single-Prase Motors.

Hp.	Condenser-Start		Split-Phase	Repulsion-Induction	
	Volts				
	110	220	110	110	220
1/8	....	....	17	13	....
1/6	22	....	28	13	....
1/4	23	....	29	14	....
1/3	23	12	30	19	....
1/2	....	16	37	26	14
3/4	....	23	60	38	20
1	....	30	....	....	25
1½	....	....	....	....	34
2	....	....	....	....	41
3	....	....	....	....	58
5	....	....	....	....	95
7½	....	....	....	....	150

Table III—Average Starting Power Factor of Motors.

Type of Motor	Power Factor
Single-Phase	
Capacitor-start	0.85
Split-phase	0.75
Repulsion-Ind.	0.65
Three-Phase	
Squirrel-cage	
Under 3 hp.	0.40
Over 3 hp.	
Normal-torque	0.35
High-torque	0.60
High-slip	0.65

3. The supply voltage (E) on the secondary or service.

4. The starting current (I) of the motor.

5. Power factor of the motor at starting.

6. Length of secondary or service circuit (L).

The general procedure is then as follows:

1. Determine the allowable percent of voltage fluctuation from Chart I.

2. Determine the percent R and percent X at the transformer from Table IV.

3. Convert the allowable percent voltage fluctuation to allowable percent of transformer and secondary impedance drop by use of Chart II.

4. Determine the percent voltage drop in the transformer and the percent resistance drop in the secondary or service conductor from Chart III.

5. Obtain the required conductor size of resistance in ohms per 1000 ft. from Chart IV.

Blade Tips—Approaching 100 MPH

IN A STEAM turbine the limit to volume of steam flow, and hence to economical capacity, is set by the length and diameter of the blades in the last row. As the blades get longer the centrifugal forces tending to pull them out by their roots become enormous. Also the velocities of the blade tips at high turbine speeds become very large—which places emphasis on the best airfoiling.

Heretofore, the longest blade for the 3600-rpm turbines has been 20 in. The new blades, designed by Westinghouse Engineers and soon to undergo tests, are 23 in. long. At 3600-rpm this will mean a blade-tip velocity of 1520 feet per second—one third greater than the speed of sound. They will make possible steam turbines that can deliver 40,000-kw from a single-cylinder 3600-rpm condensing unit or 80,000-kw from a tandem 3600-rpm condensing unit. These outputs compare with 30,000-kw and 65,000-kw of the present largest 3600-rpm machines.

Table IV—Percent Resistance and Percent Reactance of Distribution Transformers*

Transformer Rating, Kva	Allis-Chalmers		General Electric		Kuhlman		Line Material		Moloney		Standard		Wagner		Westinghouse	
	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$	$\%R_T$	$\%X_T$
1.5	2.37	2.08	2.67	2.11	2.60	1.46	2.80	1.33	2.73	1.67	2.60	1.31	2.25	1.31	2.78	1.15
3	2.08	2.04	2.33	2.50	2.16	1.56	2.53	1.61	2.40	1.80	2.27	1.80	2.26	1.80	2.47	1.52
5	2.25	1.79	2.30	2.08	2.16	1.44	2.30	1.93	2.42	2.10	2.20	1.90	2.20	1.99	2.22	1.30
7.5	2.00	2.21	2.15	1.64	2.27	1.60	2.08	2.02	2.27	2.34	2.15	1.80	1.81	1.69	2.06	1.15
10	1.85	2.25	2.00	1.96	1.90	1.84	2.00	2.10	2.02	2.26	2.00	1.90	1.83	2.11	1.79	1.75
15	1.53	2.24	1.72	2.21	1.78	2.52	1.65	2.39	1.82	2.87	1.72	2.20	1.65	2.29	1.58	1.80
25	1.42	2.57	1.51	2.36	1.47	2.40	1.47	2.50	1.53	3.14	1.51	2.40	1.36	2.88	1.60	2.28
37.5	1.32	2.79	1.31	2.47	1.33	3.58	1.27	2.61	1.35	2.90	1.31	2.50	1.20	2.88	1.38	2.68
50	1.16	2.91	1.22	2.52	1.04	3.60	1.23	2.62	1.38	2.96	1.22	2.50	1.08	3.30	1.34	2.44
75	1.09	2.64	1.10	4.47	1.25	3.36	1.15	4.46	1.31	3.10	1.10	3.10	1.16	3.44	1.20	3.40
100	1.13	3.07	1.12	4.46	1.23	3.46	1.13	4.46	1.24	3.10	1.10	3.20	1.07	4.41	1.20	3.70

*Rating from 1.5 kva. to 15 kva. inclusive are REA type. Rating of 25 kva. and above are conventional double bushing type. Values of R_T and X_T are from manufacturers' data as of January, 1942.

The Fundamentals of Electron Tubes

Part VI. Basic principle of the photoelectric tube . . . Photoelectric emission . . . Relation between light intensity and number of electrons emitted . . . vacuum phototubes and gas filled phototubes . . Applications of phototubes.

By Ralph B. Immel

Control Engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.

CERTAIN ALKALI MATERIALS such as metallic oxides of sodium, potassium or caesium will emit electrons when they are subjected to visible or invisible light. This characteristic of the material makes it possible to convert light energy into electrical energy. Electrons liberated in this manner is known as photo-electric emission.

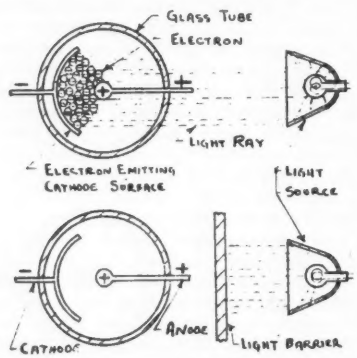


Fig. 34. Diagram illustrating the emission of electrons when cathode is exposed to light energy

A typical phototube usually has two electrodes, a semi-cylindrical cathode and a central anode, sealed in a glass tube. A typical cathode may consist of a silver base metal which is coated with caesium oxide. The caesium oxide is a light sensitive material and one of the best electron emitters among the oxides previously mentioned. The anode usually consists of a straight wire electrode which is mounted in the tube in such a position that it's axis coincides with the axis of the cathode. The anode is usually maintained at a positive potential so that the electrons which are emitted from the light radiated cathode may be attracted to it. The movement of electrons from the cathode to the plate constitutes a minute current in the order of microamperes which may be used to control some other electronic device.

Figure 34 illustrates the emission of electrons when the cathode is exposed to light energy. No electrons are emitted from the cathode when it is not subjected to light. The speed of response or the time for conversion of light energy to electrical energy is almost instantaneous. A vacuum phototube is so sensitive and fast in response that a small change in light intensity can be instantly detected. As the electron emission current is usually very small, an amplifier is used to amplify the output to a magnitude that is of some practical use.

The phototube follows definite laws stated by Einstein in 1905. The number of electrons emitted from a cathode surface are directly proportional to the intensity of the light, and the velocity of the emitted electrons depends upon the surface of the cathode and wave length of the illumination.

Typical phototubes are manufactured with either a vacuous or a gaseous medium between the electrodes. Fig. 35 illustrates the characteristic difference between a vacuum and a gas filled phototube. The characteristics of the vacuum phototube are the most stable and the output is directly proportional to the illumination. Typical vacuum phototubes may be operated with a maximum of 500 volts between the cathode and plate. A gaseous phototube will provide a greater output per unit of light than a vacuum phototube as the creation of electrons and positive ions by the collisions between electrons and gas molecules act to increase the effective tube current. The gas in this type of tube performs the same function as the gas in a hot cathode gaseous tube which was previously discussed. An inert gas such as argon is usually used in gaseous phototubes as it does not react chemically with the light sensitive surface.

Gaseous tubes are not usually operated with more than 90 volts between the cathode and the plate as a voltage which exceeds 90 volts may cause a glow discharge in the tube. Such a glow discharge will probably

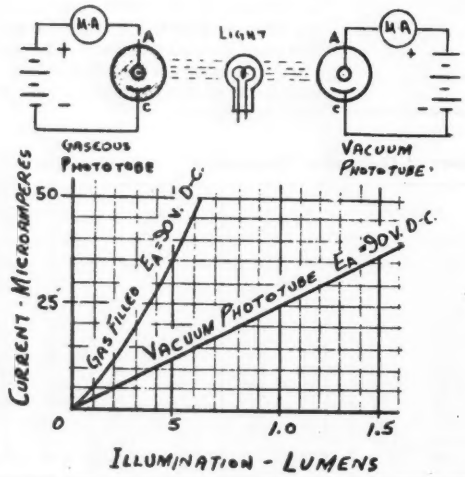


Fig. 35. Curves showing the characteristic difference between a vacuum and a gas-filled phototube

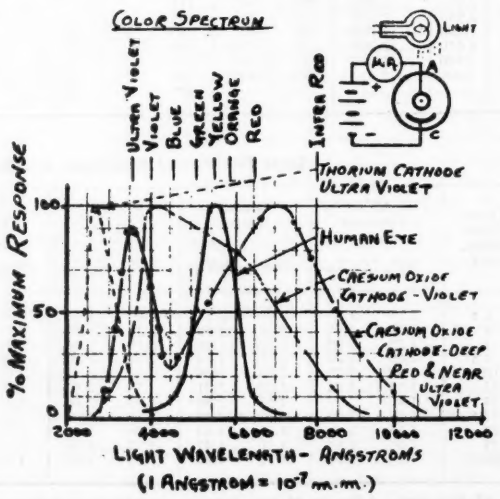


Fig. 36. Color response of various types of phototubes

WHY DO VALVE USERS ACTUALLY *PAY LESS* FOR LUNKENHEIMER VALVES?

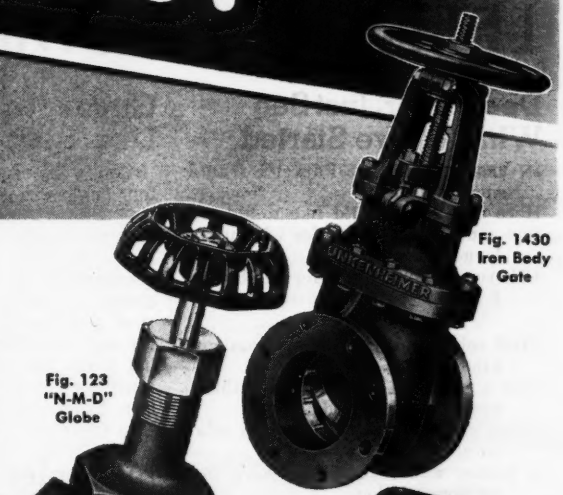


Fig. 1430 Iron Body Gate

Fig. 123 "N-M-D" Globe

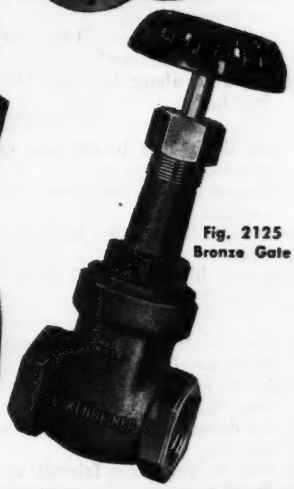


Fig. 2125 Bronze Gate

Fig. 554 Bronze Swing Check

● It's a fact, that valve purchasers actually *pay less* for Lunkenheimer Valves—because these quality-built Valves give definitely *better service, longer service, more trouble-free and economical service.*

Maintenance men everywhere know they can confidently rely on the superior performance of any product bearing the Lunkenheimer name—backed as it is by a tradition of highest quality and skilled craftsmanship.

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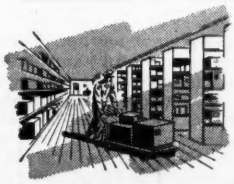

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plays a very important part in rendering the *better valve service* for which Lunkenheimer is noted. He is fully equipped and ready at all times to help you solve problems of valve maintenance or operation. Lunkenheimer Distributors are located in all industrial centers. There's one near you . . . call him for your requirements.

LUNKENHEIMER VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S. P.; BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

destroy the sensitive cathode surface and the tube will lose control of the plate current as when a discharge once starts the current will be independent of the illumination.

Phototubes are manufactured with the maximum response in a certain spectral region. Typical tubes are available for response near ultra-violet, deep red and near ultra-violet, violet, and for wave length regions of 1700 to 2700, 2500 to 3200, and 2500 to 3650 angstroms wavelength of light. Figure 36 shows the response characteristics of several phototubes with relationship to the visible spectrum. An angstrom unit is a wave length of .0000001 millimeter. (1 x 10^{7} mm.)

Phototubes are inherently suited for the control of lightning, starting and stopping of mechanical operations, and for counting operations. The tube may also be used to record the density of smoke, or solutions, or to detect the presence of smoke or fire. This tube is sensitive enough to discriminate the difference in size, thickness, and color of objects. Phototubes are recommended for any application where friction should not be introduced or a mechanical connection cannot be made to the device. With phototube control, elevators can be accurately stopped at floor positions, paper can be accurately cut with respect to certain designs printed on it, doors can be opened or closed, and many safety functions can be performed. The application of a phototube to a motion picture machine to translate the film sound track into audible and intelligible sound is a very common and practical application.

LETTERS AND COMMENTS

Deer, Deer, Just See What We've Started

IN RESPONSE to Art Parker's frantic request,
Here is a solution I'd like to suggest
For controlling the antics of four legged deer.
(There are no controls for the bipeds, I hear.)

First set up an eye, the electronic kind,
Aim a beam of black light (outfits aren't hard to find).
When a deer breaks the beam a relay would close,
A buzzer would buzz, and you'd pull on your clothes,
To go out and inform him "no time for buck passing".
Take a rifle along to make the cure lasting!

If you don't like to get out of bed summer nights
To discuss with a deer your property rights,
You might try a horn instead of the buzzer,
Then only his tracks will show where he was sir.

A fence on three sides charged with high e.m.f.
Might persuade the invader to cross the light path.
If this doesn't work, I suggest a roof garden,
Or wait 'til your deer friends' arteries harden.

As a last resort you could try hanging this above the vegetables.

Conneaut Lake, Pa. MEARL ELLISON

(Substation operator, Pennsylvania Electric, Meadville, Pa.)

Guess He Just Doesn't Like Henry Wallace

YOU CERTAINLY must be hard up for engineering material for your magazine when you have to come up with an article by the nit-witted Mr. Henry Wallace.* I presume that you contributed in cash for the tripe he dishes out, and I want you to know that you can presume that I am through contributing to any engineering periodical that has to go as far afield as you have from your senses.

San Francisco, Calif. R. J. FUITE

*What Leaders say. P. 73. Sept. 1945.

Interpoles on D-C Motors and Generators

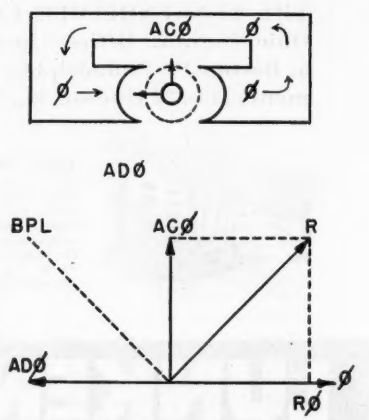
I WAS CONSIDERABLY interested in the article by Captain Eugene George Key on Interpoles on D-C Motors and Generators, appearing on page 102 of the July issue. Reading the article brought back to me certain comments by Charles Protious Steinmetz under whom I studied and who was never loathe to try to put the exact meaning of anything into words. For example, in paragraph 3, column 1 on page 102 of Mr. Key's article the word *induced* is used in relation to *current*. This, on the basis of what actually happens, is a misnomer since current without appreciable potential, induced or otherwise, is impossible. Some years ago, I had some correspondence with S. P. Thompson, the author of "Dynamo Electric Machinery" and "Elementary Lessons in Electricity and Magnetism," as he used the term *induced currents* quite frequently. Upon writing to him, he admitted the shortcomings of the term to me with somewhat poor grace. Nevertheless, his book on Elementary Lessons in Electricity and Magnetism is one of the best ever written on the subject in my opinion, especially considering the range of thought it holds between its covers.

To continue, however, in "Principle 2" in column 2 on page 102 of Mr. Key's article, line 10, the word *oppose* might have been more expressive and descriptive than *resist* since it is due to a counter emf and counter emf applies opposition to the impressed voltage. On page 103, column 3, paragraph 3, of Mr. Key's article also, it would have been more correct to have said *since the value of the magnetic distortion* instead of simply *magnetic distortion* as Mr. Key puts it.

Actually the conditions that exist are those shown in the accompanying illustration. The vector diagram, it will be noted, gives R to resultant flux so the brush position without interpoles would change from ACϕ at no load to BPL at full load. The use of the interpole would neutralize ACϕ and ϕ would be reduced to Rϕ by ADc giving us R net.

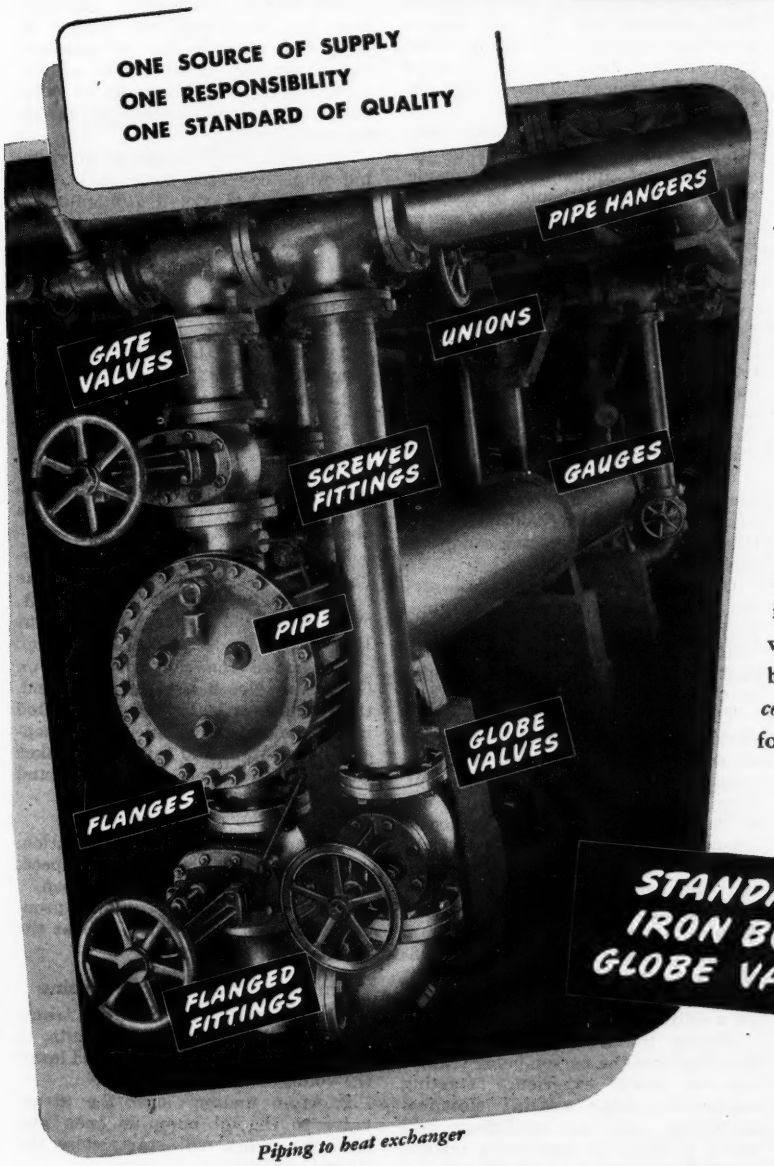
I realize, of course, that Mr. Key's article is essentially to be regarded in an elementary way, so too much hypothetical comment is not in order. This subject of interpoles, however, reminds me that when I was on test at the General Electric Company some strange things were done, such as trying to put a shunt on the commutating field with disastrous results. The commutating field is a fixed part of the armature in its function. As a matter of fact, I have seen motors of earlier types actually hunt at light load when the load was suddenly removed due to commutation pole saturation and the use of a shunt.

When I was employed at one of the large steel mills in India some years ago, we had a very large d-c motor with its own fly-wheel motor generator set on one of the main blooming mills. The motor was a 7500 hp 150 rpm reversible unit and



Flux conditions and vector relations of flux in a motor main field flux ϕ. Armature demagnitizing flux AD ϕ. Armature cross magnetizing flux AC ϕ

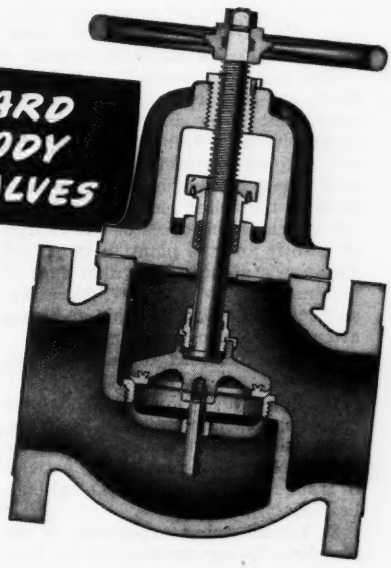
For "User's Choice" of Piping Materials ... it's the Complete CRANE Line



Piping to heat exchanger

Piping systems operate under varying conditions. What conditions should dictate your choice of piping materials, you can best determine. Then Crane helps you meet those specific requirements with the world's largest line of valves, fittings, pipe and piping accessories for all applications. By demonstrating the merits of all types of materials, Crane, with 90 years' experience, enables you to choose correctly for every need.

Ordering from the Crane line simplifies all piping jobs. Your Crane branch or Wholesaler supplies all materials. You're sure to get a better installation and better performance with all parts of uniform quality, backed by single responsibility. This *complete* Crane service is *made-to-order* for your peacetime program.



SERVICE RECOMMENDATIONS:

Crane Standard Iron Body Globe and Angle Valves meet all general service requirements with working pressures up to 125 pounds steam. Brass-trimmed valves are recommended for steam, water, and fluids non-corrosive to brass or iron; all-iron valves for fluids that corrode brass but not iron. Also available with choice of composition discs for steam, hot water, cold water, air, oil, and other services. In sizes from 2 in. up—with screwed or flanged ends. Crane also makes iron body globe and angle valves in all-iron; with brass trim; and with composition disc; in sizes from ¼ to 2 in. Rated at 150 pounds steam, 250 pounds cold. See your Crane catalog, pages 143 to 151.

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in addition to the commutating poles it had a pole face winding to aid in neutralizing the component ADϕ and it was truly marvelous to see this huge motor reverse several times per minute without a trace of sparking at the brushes even though some of the blooms were partly cooled when they first passed through the rolls and the only adverse effect I ever saw was the breaking of a roll. The motor was a tribute to the modern design of motors—U. S. A. General Electric Company's. It was installed about 1921 or 1922. It was some job to cut an armature coil out of this motor as I learned by sad experience. We had a spare armature but the change could only be made during the week-end shut down due to a heavy production schedule. It was interesting at the control stand to have the Sikh, Moslem and Hindu each with a different type of dress. The Sikh with his long black beard and a name ending in Singh, meaning "warrior."

C. O. VON DANNENBERG

Training of Practical Engineers

FRED D. MOSHER'S article in October POWER PLANT ENGINEERING brings out many interesting ideas in training power plant employees. Due to the fact that power plants vary so much in size and purpose, only a general outline can be given. The smaller the plant, usually the poorer are the training programs. Too often men are just allowed to advance automatically as vacancies present themselves because of seniority or pull.

The words "operator" and "engineer" are used in so many different ways that it is difficult to discuss them without defining them first. We will call an operator one who operates the switchboard; in the turbine room or the boiler room. An engineer (or watch engineer) is one in charge of a shift and the plant in the Chief Engineer's absence. He takes care of turbine and switchboard operating, and out of the corner of his eye looks after the station auxiliaries.

The qualifications for an engineer should be:

1. High school education and some supplementary education is desirable. This will make it easier for him to read, study, and understand articles in trade magazines and technical publications.

2. Actual firing experience is desirable so he can understand the fireman's troubles in maintaining proper CO_2, steam pressure, superheat, etc. Preferably some of the experience should be on the actual equipment in use.

3. He must be responsible for he is in charge of the whole plant.

4. Not the least important, he must have a personality that enables him to get along and work with the men on his shift.

Training men for the position of engineer is most often very sadly neglected because no course of training has been set up in smaller plants. Each engineer has his own way to do things; such as starting up a *turbine*, boiler, feed pump, or other pieces of equipment. This is very confusing to a new man.

To overcome this, very definite operating routines should be set up for each piece of equipment, and no deviation from this should be allowed. These routines are not hard to set up and can usually be produced by cooperation between the Chief Engineer and the engineers.

If no one-line diagrams of the steam, condensate, or gland water lines are available, they should be drawn up. In most any plant some one has the ability to do this if given a chance. It may be an engineer, a fireman, helper, mechanic, or the Chief Engineer himself.

One-line diagrams of the electrical portion of the plant should be made and definite operating routines established to cover all operating conditions and equipment failures.

One-line diagrams are necessary for the average person being trained is just confused trying to follow a steam or condensate line on a drawing that has every piece of pipe and valve in the plant on it.

The man selected for training should have had enough experience in maintenance around the plant to become familiar with the plant layout. Then he should be turned over to one of the other engineers for a period of intensive training. The length of the training period will vary some upon the man being trained. Six or eight weeks should enable the average man to take over a shift. He will not be a finished engineer in this time as confidence in himself and the equipment come only after a long period of time on a shift by himself.

During the training period, it is essential that the person being trained has as much experience starting equipment, doing actual electrical switching, etc., as conditions will allow. It does the man being trained much more good to actually start a turbine and its auxiliaries and to synchronize and put it on the station bus once than could be gained in a week of study. Small mistakes should not be criticized too severely, and good work should be praised.

Selecting an engineer for this task is just as important as selecting the trainee. He must have patience, he must repeat the same explanations a hundred times, if necessary. Above all, if he does not have a positive correct answer to any question asked, he must be able to admit it as there is no surer way of him losing the respect of the trainee than to give an explanation that is later proved wrong.

Any drawings of plant layouts, operating routines, or other plant data should be made available to all plant employees. The ones that want to advance, will take advantage of it.

Any number of budding engineers have had their ambitions nipped by continued refusals for information; either because of ignorance of the person asked, or an idea by an older engineer that all knowledge should be kept to oneself.

Shown herewith is one sheet showing what has been done in a small plant.

ERVIN O. SCHMOKER,
Wilmette, Ill.

Starting No. 2 Turbine

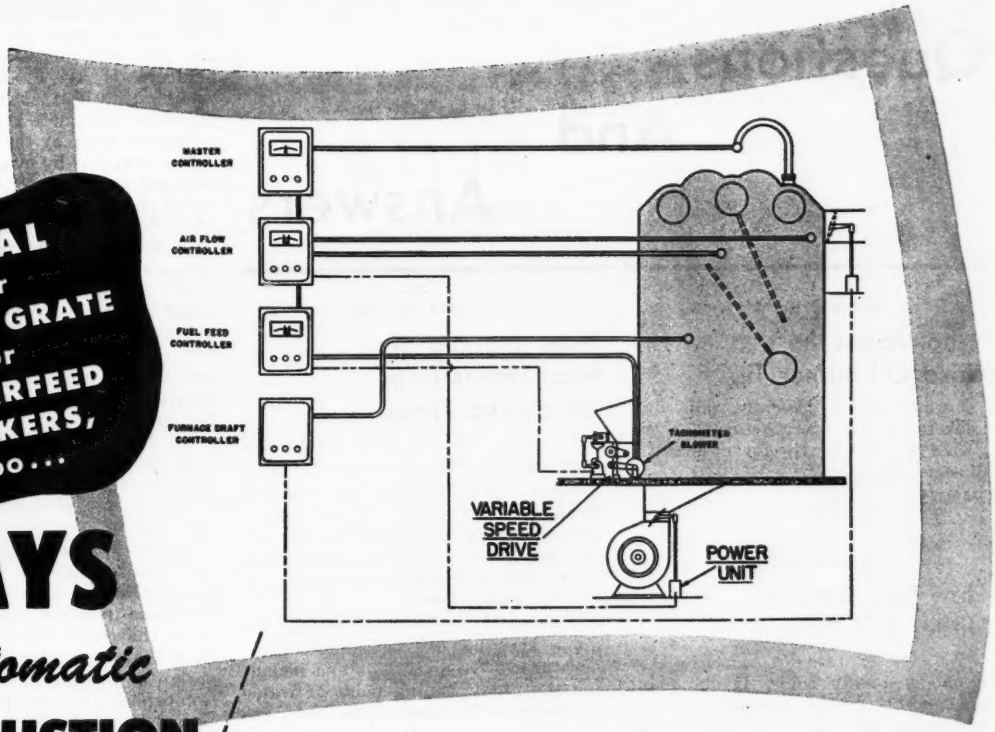
Notify the fireman approximately the time you will be ready to start up.

1. Open the by-pass on the header valve and put the steam traps in operation.
2. Start the circulating pump.
3. Open the header valve and close the by-pass. Start the oil pump. Tell the fireman you are ready to start.
4. Open the throttle valve until the turbine turns over and then close to about 25 psi.
5. Close the throttle valve and casing drains and when the turbine has reached a speed that will permit, open the gland water valve (about 1200 R.P.M.).
6. Because the collector rings on Generator No. 2 are out of round, their discoloration can be prevented if the exciter switch is closed to separate excitation and the field breaker closed at the same time the gland water is turned on.
7. Start the condensate pump.
8. Place the air jets in operation.
9. When the turbine is up to speed, open the throttle valve—wide open.
10. If the turbine is running properly (vacuum okay, etc.), adjust the voltage and synchronize.

Shutting Down No. 2 Turbine

1. After the load has been transferred to the other unit, or units, in operation; open the breaker and lower the voltage.
2. After making sure the steam valve to the oil pump is open and that the pump will start, close the throttle valve.
3. Open the vacuum breaker.
4. Close the steam valve to the air jets.
5. Shut down the condensate pump.
6. Open the throttle valve and casing drains.
7. As soon as the voltage has dropped to about zero, the field breaker and the exciter switch can be opened.
8. When the turbine stops rolling, close the header valve.
9. Shut down the circulating pump.
10. Close the valves to the steam traps and open their drains.
11. Close the steam valve to the oil pump.

IDEAL for CHAIN GRATE or UNDERFEED STOKERS, too...



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...HOLDS STEAM PRESSURE CONSTANT...AND EFFICIENCY AT ALL RATINGS IS UNIFORMLY HIGH

Primary unit of the Hays System is the Master Steam Pressure controller. Connected to the main steam header, it controls the operation of other units in the system—makes certain that they supply the correct amount of air and fuel to maintain steam pressure constant and the efficiency of all ratings uniformly high.

- ***Air Flow Controller*** — measures the rate of air flow by taking the draft loss through the boiler; and operates the forced draft inlet damper to maintain the correct rate of air flow for efficient combustion.
- ***Fuel Feed Controller*** — varies the stoker-speed-control device, measured by a tachometer blower, to maintain the correct rate of fuel feed in relation to the rate of air flow.
- ***Furnace Draft Controller*** — operates the boiler outlet damper, to maintain the furnace draft constant at the predetermined value for which it has been adjusted manually.

Result: Steam pressure is maintained constant regardless of fluctuation in steam demand; and a highly efficient rate of combustion is maintained with corresponding saving in fuel.

Applicable to any method of fuel feed, and to the use of any kind of fuel in any size of power plant, Hays Automatic Combustion Control has the outstanding advantage of all-electric operation with all its important economies. Also it may easily be switched, when and if desired, from automatic control to manual operation in full or in part.

For full details and application drawings for 14 different systems, write for Bulletin 46-605.

HAYS

THE MODERN SYSTEM . . . *it's electrical*

Automatic COMBUSTION CONTROL

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

Questions And Answers

Question No. 317

Who Makes the Crisp Oil Burner Tip?

I would like to have the name and address of the manufacturer of the CRISP oil burner tip for mechanical pressure burners.

New Haven, Conn. W. S.

Question No. 318

How Burn Butane Under This Boiler?

WE ARE INSTALLING an Erie City Economy 150-hp boiler at our plant next month. We are considering using butane gas as fuel for we have a supply of that gas available but have no natural gas in this territory.

If you have any information about a set-up for doing this—such as details of burners, tanks, and the like—also about what it might cost to burn butane as compared to coal, I would like to have it.

Texas C. L. H.

Question No. 319

What Should His Fuel Oil Temperature Be?

I AM BURNING No. 5 fuel oil with a flash point from 190 to 230 degrees closed cup. When this is all the information I have about the oil, what do I do to find out what the temperature should be off the fuel oil heaters? Do you have a formula to show how this is done?

I have a table showing the heater and atomizing temperatures for oils of various viscosities, but when I get only the flash point, then I'm at a loss what to do. I understand I have to make an allowance of 10 degrees to avoid carboning up the fuel oil heaters. But 10 degrees from what?

Lakehurst, N. J. J. C. P.

Editor's Note—Ordinarily the suppliers of the oil should be able to supply the above information, but we suspect the trouble in this case is that the oil comes from a number of unidentified sources of supply. We shall appreciate further comments from readers.

Question No. 320

Data Wanted on Heat Losses from Uncovered Tanks

I WOULD LIKE a table giving the heat losses by evaporation and also by radiation (to be given as separate figures) as transferred to the atmosphere from the water surfaces of uncovered tanks or vessels, either from water only or solutions containing for the most part, water.

Preferably these losses should be given starting at atmospheric temperatures of 75 or 80 F to and including the 212 F boiling point of water in 10-degree divisions. The losses are to be calculated from atmospheric temperatures of 60 F, assuming still air.

Also, a table giving heat losses at the same water temperatures from metal wall areas of tanks would be appreciated.

I have used a table for some time that presumably gives this information, but from actual experience, it has been found that the heat losses given are much too low, and we have been forced to discontinue the use of this table.

Los Angeles, Calif. C. C. S.

Tank Radiation and Evaporation Losses

IN THE CALCULATION of heat losses it makes considerable difference whether the results are to be used for design purposes or for heat balance.

The net heat loss or gain from a metal vessel will depend primarily on

1. Type of surface
2. Wind velocity
3. Solar condition
4. Bearing soil

A pamphlet by International Nickel Co. headed "Heat Transfer Through Metallic Walls" shows that surface film has many times the effect on heat transfer as does the type of metal or its thickness. An unpainted black surface may have twice the radiation loss of one coated with a thick synthetic-base aluminum paint.

A vessel subject to a 10-mph wind will have a considerable greater heat transfer than one in a relatively still atmosphere.

A vessel exposed to bright sunshine may even absorb heat rather than lose it even when the liquid is 90 F and the atmospheric dry bulb temperature is 70 F. It depends on whether the heat absorbed by radiation from the sun is greater than that conducted away by the air.

The heat loss by evaporation is just as hard to calculate. On large open tanks, the heat absorbed by the water from the sun may exceed the cooling effect from evaporation at the desired temperatures. I have seen swimming pools, stock watering ponds, and water tanks (in the Southwest) when the water temperature exceeded the dru bulb temperature by 10 F and unless fresh water is added the temperature always exceeds the wet bulb. On the other hand, a tall vessel with a low liquid level may not lose much heat from the surface even if the sides shade the liquid surface. There is not enough circulation to promote evaporation.

All of this seems to indicate that I am side-stepping the issue, but what I am trying to do is to point out the weakness in using any data for purposes that were not intended, and to show that most available data are for design of heating systems, refrigeration capacity requirements and insulation thickness.

I would be very happy to undertake the preparation of curves covering:

1. Heat loss from tank walls for various finishes and temperature differences;
2. The losses from still, shaded, surfaces subject to at least thermal convection;
3. Heat losses through the bottom;

But if the questioner is interested in only rough figures for design he may find the following data useful:

a. Heat loss from flat surfaces—Kent, Page 3-64
b. Heat loss by evaporation ponds—Kent, Page 9-23
c. Evaporation to atmosphere—Kent, Page 3-48
d. Heat transfer to earth—Air Conditioning, Heating and Ventilation by Power Plant Engineering, 1936 Edition, Page 52.

Houston, Texas

BILL MADDOCK.

Editor's Note—"Kent" is, of course, Kent's Mechanical Engineers' Handbook, Power Volume, 1936, 11th Edition, John Wiley & Sons, Inc., New York.

Answer No. 296

Should These Turbine Generators Be Installed Or Should Power Be Bought?

Engines Would Be Better, White Believes

IN LOOKING over the September issue, I found the answer to question No. 296, by Alfred W. Fox, of interest.

135°F ± 1°F *Through* FOSTER REGULATION ENGINEERING

Solution temperatures at 135°F plus or minus 1°F are maintained in this Bonderizing equipment, with Foster Type 34-T Temperature Regulators. They control the flow of steam to the heating coils immersed in the tanks. The work is carried through the tunnel in the background, where it is successively sprayed with solutions, which drain back into the tanks. Close control of solution temperature is essential to continuous automatic operation.

IT'S an easy matter to select the *right* temperature regulator, when you have the complete Foster line to choose from. For Foster Regulation Engineering assures the simplest trouble-free installation—by making available a temperature regulator tailored to each type of application—by selecting the one exactly fitted to your needs—and by assisting on sound installation practice.

In the Bonderizing installation illustrated, the problem was to hold solution temperatures as close to 135°F as practical without unnecessary complication. The Foster Type 34-T was selected from the entire Foster line because it is a simple basic unit capable of holding temperatures to within 1°F plus or minus. Elaborate layouts and complicated equipment were avoided, because, in this case, the 34-T fits the job.

Foster Regulation Engineering insures satisfactory performance, cuts cost and saves maintenance time.

Foster Temperature Regulators—for steam, air, liquids and gases—are available for pressures up to 450 p.s.i. and temperatures to 300°F. Temperature adjustment range of 110°F and regulation accuracy of ± 1° are available in the line. For complete details, ask for Bulletin 11.

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PRESSURE REGULATORS...RELIEF AND BACK PRESSURE VALVES...AUTOMATIC STOP AND CHECK VALVES...ALTITUDE VALVES...DAMPER REGULATORS...FAN ENGINE REGULATORS...PUMP GOVERNORS...TEMPERATURE REGULATORS...LIQUID LEVEL CONTROLLERS...FLOAT AND LEVER BALANCED VALVES...NON-RETURN AND TRIPLE DUTY VALVES...VACUUM REGULATORS OR BREAKERS...SIGHT FLOW BOXES...STRAINERS...SAFETY VALVES...SIRENS

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1-FE-1

I would like to point out that the demand charge plus the rate charge should be the price paid for 136,000 kwhr per month. Thus we have the following known expense:

136,000 kwhr × 1.6 cents + $740 × 12.	$34,992.00 per yr
Heating steam, 6M × 21.9 cents × 24 × 240 days	7,600.00
Known cost of power and heating	$42,592.00
Taking Mr. Fox's figures for it:	
Cost of power for a year	$26,112.00
Heating steam for a year	7,600.00
Known cost of power and heating	$33,712.00
Cost of coal to produce one week's power	$444.00
Cost of coal to produce for year's power	23,000.00
	$10,712.00

In this case the average water rate per kwhr is close to 65 lb, which seems high, and would be less during the non-heating season, as there would be no back-pressure.

I do not think turbines are the answer in this case. I am of the opinion that with reciprocating units a lower steam rate would result. Two units should be considered, which would handle the peak load nicely, the smaller one to take care of the light load.

WM. S. WHITE.

Hammond, B. C., Canada

Answer No. 309

Why Doesn't This Power System Operate Right?

Analysis by von Dannenberg

THE LOAD cannot be divided as planned, utilizing all three phases due to the existence of a partial or complete short circuit when the loads at Aand B have their neutrals grounded and are connected to different phases. This is clearly indicated in the appended diagrams.

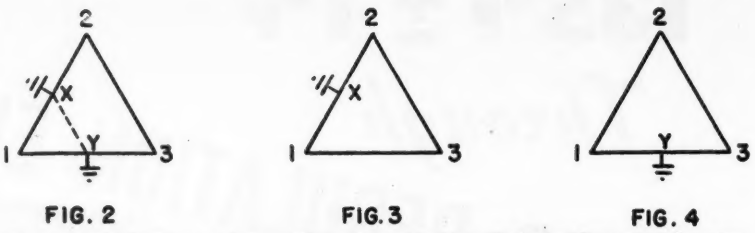

FIG. 2 FIG. 3 FIG. 4

Fig. 2, 3, and 4. Diagrams by von Dannenberg showing effect of various ground connections on different parts of the system

Figure 1 is essentially the same as given in the question, except that loads (A), (B), and (C) are shown connected to generator (E) respectively to phases 1-2, 1-3 and 2-3.

Figure 2 shows the system with phase 1-2 grounded at its midpoint x and phase 1-3 grounded at its midpoint y. With this arrangement there exists between phase 1-2 and phase 1-3 a potential (voltage) difference of x - y equal to 110 v. It follows then with low resistance in the ground circuit x - y, a current will flow, and if the resistance is sufficiently low, will interfere with the operation of the system in this way; a direct connection between x and y would be a complete (dead) short circuit. It is not apparent why a fuse should be indicated in the ground connection of load (B).

While it is not stated why the grounds are required, there are regulations in some areas limiting the maximum voltage to ground to 150 v and, depending upon how closely this requirement must be complied with, some suggestions concerning its attainment are indicated as a guide.

For Fig. 3 the respective voltages to ground are:

Line	*Volts*
1	110
2	110
3	190

For Fig. 4 the respective voltages to ground are:

Line	*Volts*
1	110
2	190
3	110

Should only circuit (A) be the one to have maximum ground voltage, then only one neutral should be grounded as in Fig. 3.

If uniform voltage to ground is desired from all three lines then an arrangement shown in Fig. 5 will be suitable. This consists in providing a 3-phase bank, F, G & H, connected in star on the 220-v side, with the neutral grounded, and the other side in closed delta. This arrangement will give 127 volts to ground from all three lines 1, 2 and 3. The total capacity of the bank is a matter of judgment and experience and the writer has used capacities varying from 10 to 25 per cent of the generator with satisfactory results.

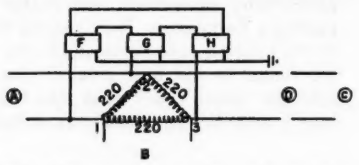

Fig. 5. Diagram by von Dannenberg showing how 3-phase transformer can be connected to give 127 v to ground from all three lines

Brooklyn, N. Y.

C. O. VON DANNENBERG

Analysis by L. R. Boyer

The problem of the pump circuit seems to have been inserted for good measure, as it has no bearing on why operation can not be effected as a balanced 3-phase system.

The phenomenon of a voltage reading to the lead sheathed cable conductors is due to the electrostatic capacity of the cable. The fact that only 55 v was shown was a clear indication that the cable was free of grounds, else a reading of 110 v would have been obtained. Had the grounds on both A and B transformers been removed, no definite voltage above ground would have existed and the voltmeter might have read more or less, depending on the electrical characteristics of the system as a whole and the sensitivity of the voltmeter.

With the load connected for 3-phase operation as shown schematically in

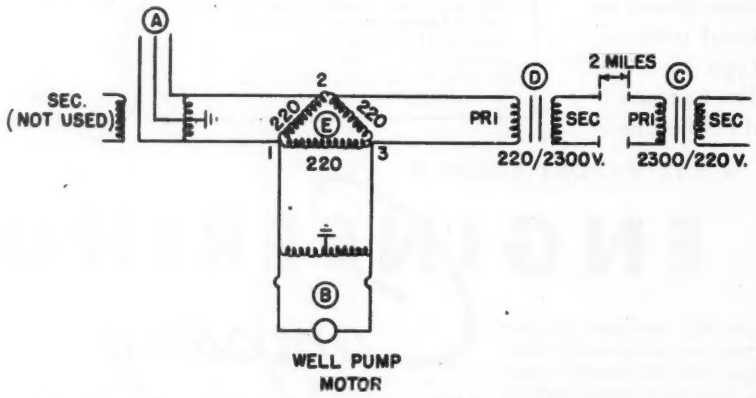

Fig. 1. Diagram of power system by von Dannenberg, showing connections at present

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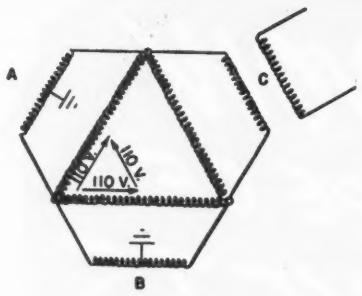


Diagram by L. R. Boyer showing how grounds unbalance the circuit

accompanying sketch, it is at once evident from the phase relationship that the mid points of the two transformers A and B are not at the same potential; a difference of 110 exists. If both mid-points be grounded, the low impedance path through the ground connections would result in a dead short circuit on the system.

When connected in parallel for single phase operation the mid points are at the same potential and ma ybe tied together, as through ground connections, without adverse effect.

There are two answers to the grounding problems. If it is merely desired to prevent the voltage of the 220-v generator and circuits as a whole from being raised to dangerous potentials, above ground, through electro-static coupling with the 2300-v side of the transformers, grounding any one of the three 220-v conductors, preferably through a fairly high resistance, would suffice. If 110-220-v service for lighting is desired at one point, then grounding the mid point of the particular transformer concerned would be in order, which would insure holding the potential of two phases of the 220-v system to 110-v to ground. The third leg would be at 86 percent of 220 or 189-v to ground.

Jacksonville, Fla. L. R. BOYER.

Answer No. 312

What Happens When Air and Water Meet?

H. H. L. in the November issue states that 1 lb of air at 70 F. dry bulb and 70 F. wet bulb is equal to 13.34 cu ft in volume at 29.92 in barometric pressure and that air under these conditions will hold 110 grains of moisture. This is true. He then asks what makes up the other 6890 grains in the pound of the mixture?

Editor's Note—The statement of this problem in the November issue should have read "one cubic foot will hold 8.23 *grains of moisture;* 13.34 *cu. ft. will hold* 8.23 *times* 13.34 *(instead of 'that') which is* 110 *grains of moisture.")*

The 6890 grains remaining consists of dry air, which may be broken down as follows:

Nitrogen	5200 grains
Oxygen	1598 grains
Carbon Dioxide.....	3 grains
Argon	89 grains
TOTAL	6890 grains

Air also contains very small quantities of neon, helium, krypton, and xenon.

St. Louis, Mo. JOHN A. YUNGBLUTH.

His Psychrometry Is Confused, Says Sanford

I THINK the thing that is troubling your reader who has sent in Question No. 312 is the fact that he is confusing a pound of air at a certain psychrometric condition (air and water mixture) with a full yound of water (no air present).

For example, one pound of air at 70 F dry bulb, 70 F wet bulb, 70 F dew point, 100 per cent relative humidity is in a saturated condition. But a pound of air in this state contains only 0.01578 pounds of vapor (taken from psychrometric chart). The balance of the pound (1-0.01578 or 0.98422 lb) is air.

In other words, a pound of air at the specified condition will hold only 0.01578 lb. vapor x 7000 grains or 110 grains as your reader has calculated. Assuming that the remainder of the pound or .98422 lb were vapor instead of air, the equivalent vapor in grains would be .98422 x 7000 or 6890 grains.

I trust this analysis will clear up your reader's problem.

E. C. SANFORD.

San Francisco 5, Calif.

Answer No. 313

Can This Boiler Be Changed To Give Dryer Steam?

Install a Dry Pan, Says Webber

PRODUCTION of 85 per cent dry saturated steam from a modern watertube boiler is not readily understandable. Nearly any boiler, including the HRT, will furnish 94 or 95 per cent dry saturated steam. Something is radically wrong.

To begin with, I think that the water level carried in the boiler could be cut down somewhat without endangering the equipment. Carrying the water at two inches above the center line of the drum would place the level at 20 inches from the bottom of the shell. At high ratings the level might raise to 23 inches or more allowing only 13 inches of steam space above the water which is I think somewhat limited. Lowering the water level two inches would no doubt be quite beneficial.

E. O. D. does not state whether or not his steam drum is equipped with a dry pipe or other contrivance for removing the water from the steam but I am submitting a drawing showing a dry pan and baffle arrangement that probably will help his condition.

The dry pan, to be constructed of steel plate as shown in the sketch, should be hung approximately 5 in. from the top of the drum. The width should be such as to allow about 3 in. on either side between the plate and drum shell. It should be long enough to extend to within 2 or 3 ft of each head, depending, of course, on the location of the steam outlet. Numerous ⅜ or ½-in. holes should be drilled in the plate to dispose of moisture released from the steam.

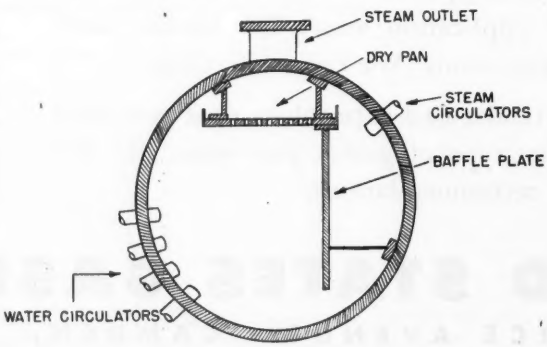
The baffle plate should likewise be of steel and attached to the dry pan as per the sketch. Its depth should be sufficient to keep it at all times below the water line and it should be long enough to cover the steam circulating tubes. It would be advisable to have 8 or 10 in. clearance at each end between the drum head and the edge of the plate.

Any water brought over through the circulating tubes will impinge on the baffle and drain to the drum while the steam will proceed at a low velocity around the ends of the plate and rise to the top of the drum, enter the dry pan and eventually pass out of the steam outlet.

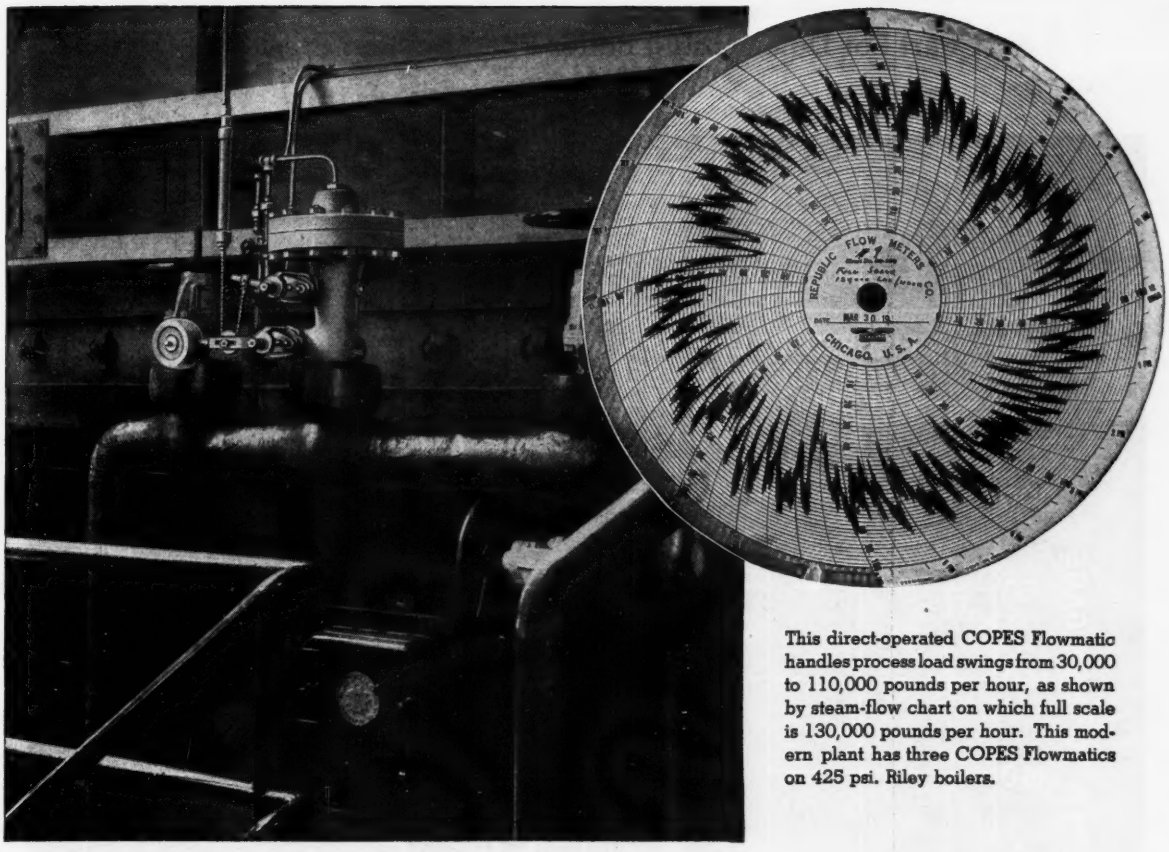
Raising the setting or boiler cover to allow a greater area of the drum shell to be exposed to the gases of combustion would also contribute toward dryer steam. Some manufacturers set their boilers so that all of the drums are thus exposed and claim superheating effects therefrom.

It might also be advisable to check the concentration of the boiler water. If this is allowed to increase beyond a certain amount carryover will result with all of its tribulations.

Duluth, Minn. E. R. WEBBER.



E. R. Webber's design of drum internals for drying steam in E.O.D.'s boiler



This direct-operated COPES Flowmatic handles process load swings from 30,000 to 110,000 pounds per hour, as shown by steam-flow chart on which full scale is 130,000 pounds per hour. This modern plant has three COPES Flowmatics on 425 psi. Riley boilers.

On *fluctuating* process loads

As the Plant Engineer expressed it: "It would be foolish to claim the water level is held constant on these rapid changes, for *no* regulator will take water away from a boiler when the sudden load comes on, as it would have to do to hold the level constant. The normal water level is at the center of the drum. As the load hits, expansion of the boiler water along with increase in gas fuel supply (combustion and pressure control) on a slight drop in boiler pressure again increases the volume of the water-steam content of the boiler and raises the level three or four inches, and will do this with no feed. This higher level is held until the stored water is used up. On a drop in load and rise in boiler pressure, the level is held constant."

No matter how severe your loads—process or power, —COPES Flowmatic assures an always-safe boiler water level. Bulletin 429-A tells how and why. Write for it—your letterhead, please.

NORTHERN EQUIPMENT COMPANY

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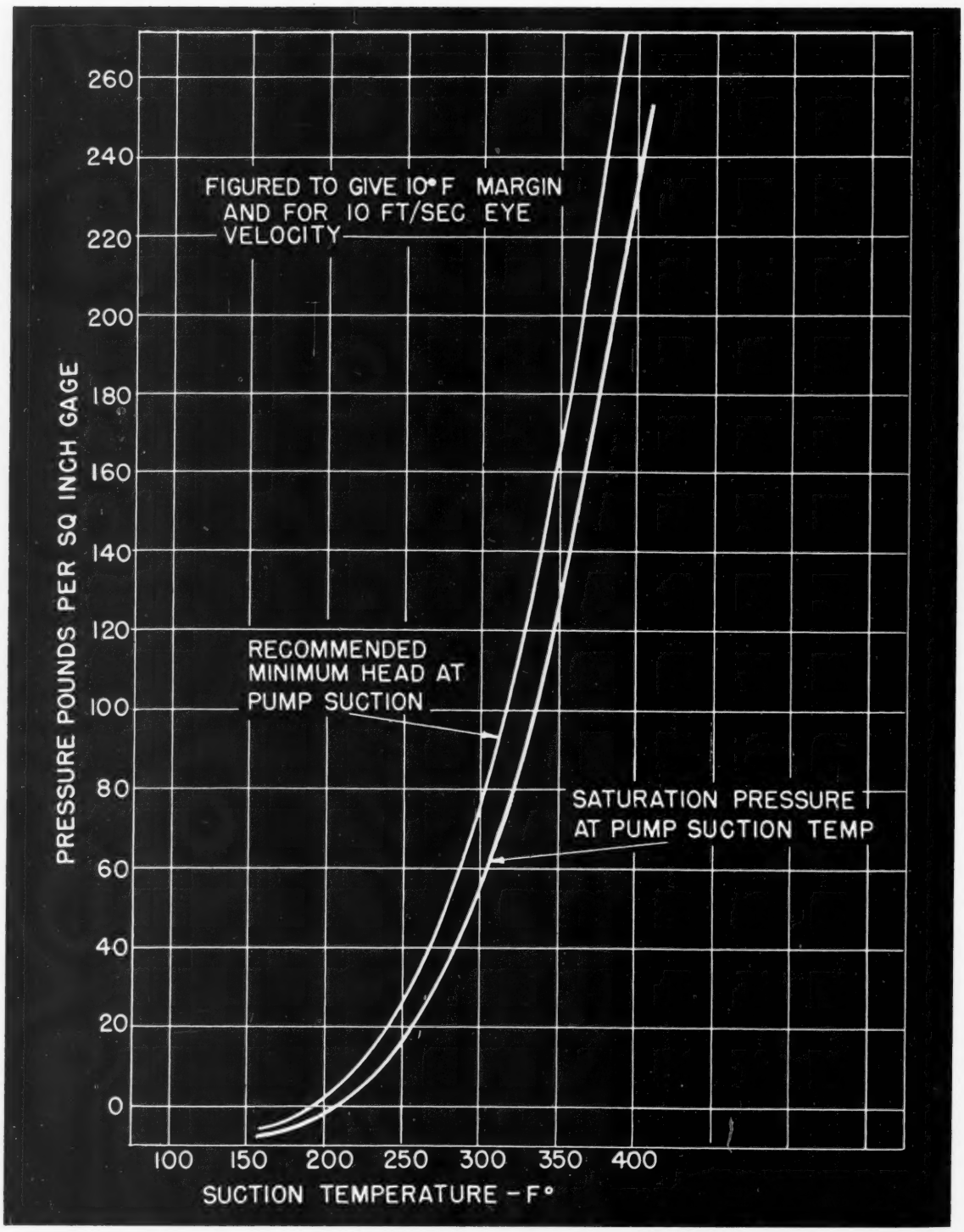
FEEDS BOILER ACCORDING TO STEAM FLOW-AUTOMATICALLY

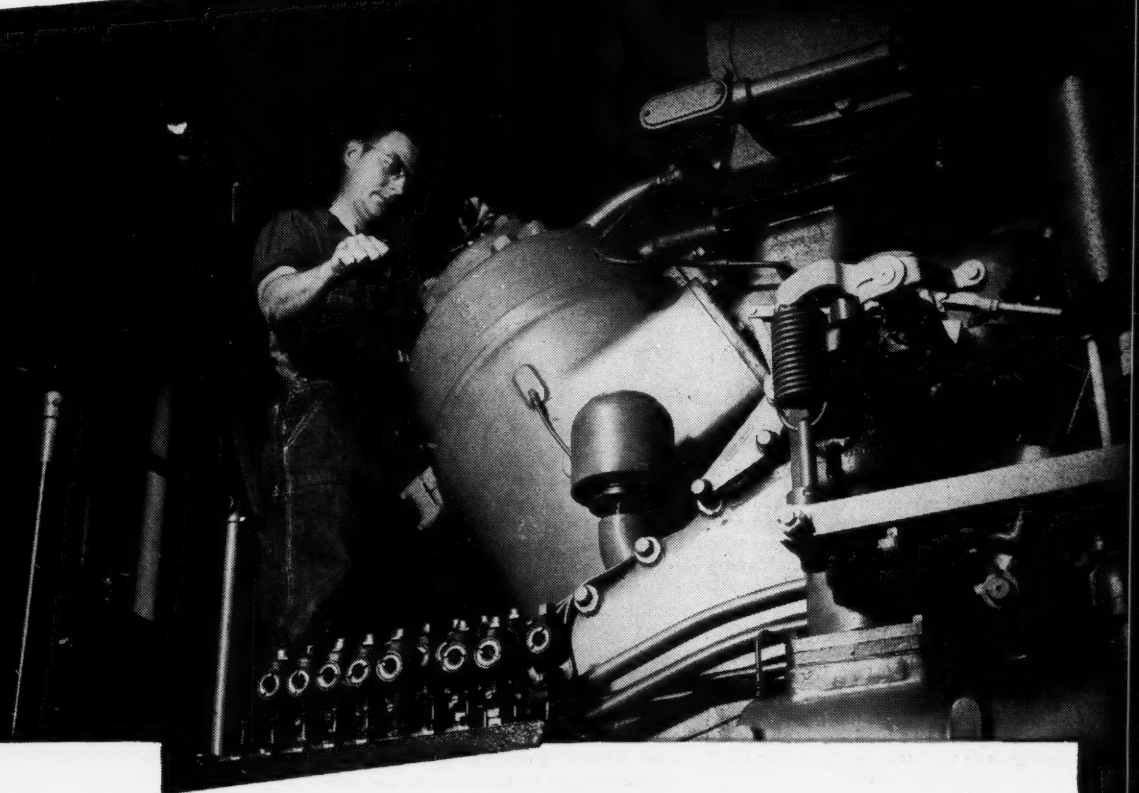
Chart For Determining Boiler Feed Suction Pressures

By Bill Maddock



This chart is handy in determining the proper boiler feed suction pressures. It is intended for a standard set-up except that it is made to cover deaerating service. The margin of safety has been increased to allow sudden load changes or bleed pressure changes encountered in practice.

20,010 HOURS OF TROUBLE-FREE OPERATION



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Installed in a huge industrial plant, one week before Pearl Harbor, these 400-h.p. units have given outstanding service. Sun Solnus Oil was used for both Diesel power and air-compressor sides from the very first day . . . was chosen for its low carbon-content . . . its ability to keep rings free and clean . . . the fact that it doesn't form harmful acids or hard, flinty deposits . . . and doesn't break down into thick, sticky sludge.

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Sun products prolong machine-life; save power, materials, and labor; not only in power-plants and factories, large and small, but throughout industry.

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What the Power Engineer Needs to Know About

STEAM COMPRESSORS

Steam compressors raise pressure of steam by mechanical compression, like an air compressor . . . Used where steam is generated at low pressure but small amount of high-pressure steam is required for special purposes . . . Construction of the compressor . . . Details of 15 installations . . . Steam pressures, temperatures, capacities . . . How install and operate compressor . . . Proper lubrication important . . . How control steam compressor . . . Power consumption . . . Costs of several complete installations

By G. D. WINANS

Assistant Superintendent of Central Heating
The Detroit Edison Co.

STEAM COMPRESSORS in most instances are slightly modified air compressors used to raise the pressure of steam in a manner comparable to that involved in the compression or increased pressure of air. In accordance with the applicable thermodynamic laws, the saturation temperature of the compressed steam depends upon the final steam pressure, and therefore is higher than that of the original or uncompressed available supply. The idea of steam compressors is not new but is being used to an increasing extent.

Why Use Steam Compressors?

Desired temperatures can be obtained by superheating low pressure steam, but for processes involving the use of heat transfer apparatus, saturated steam is much more desirable, inasmuch as the temperature remains fixed for any given pressure, and the heat transfer is higher. There is little or no gain in the available temperature when superheated steam is used in closed coils, jackets or chests, for the steam loses its superheat almost immediately and most of the heat is transferred at the saturation temperature of the condensing steam. Temperatures above saturation temperature are obtainable only when superheated steam is not permitted to condense but is exhausted continuously from the apparatus before it has lost its superheat. This obviously is uneconomical.

A steam supply of the proper pressure and temperature for many process applications is not always available and it is necessary either to install auxiliary boilers or to operate at decreased capacity and efficiency with low pressure, low temperature

Table I. Data on a number of steam compressor installations

Building	Use	Date Inst.	Bore and Stroke, In.	Inst. Motor Hp	Design Suction Pressure	Design Discharge Pressure	Mfg. Rating Lb per Hr	Type of Pressure Control	Approx. cost of Complete Inst.
Club	Laundry	1927	9½ x 12	60 d-c				Suc. pres. throttling	$6500
Clothing Store	Presses	1932	6 x 7	15 a-c	10	80	300	Stop & Start	$2600
Dept. Store	Presses	1935	7 x 7	25 a-c	30	85	600	Suc. valve unloading with air	$1600
		1938	7 x 7	25 a-c	30	85	600	Suc. valve unloading with air	$1500
Hotel	Laundry	1937	9 x 9	50 a-c	30	100	800	Bypass on disch. pres.	$1900
	Presses	1938	3 x 8	5 a-c				Bypass on disch. pres.	Revamped CO_2 mach.
Hotel	Laundry	1938	9 x 9	40 a-c	25	100	1000	Suc. valve unloading with air	$2900
	Laundry	1938	12 x 11	75 a-c	25	100	1800	Suc. valve unloading with air	$4100
	Presses	1938	4 x 4	7.5 a-c	25	100	100	Disch. valve unloading with air	$ 900
Office	Presses	1937	4 x 8	8 x 8 steam engine				Bypass on	Revamped st-driven air comp.
Hotel	Laundry	1940	14 x 13	125 a-c	15		1800	Suc. unloading	$5500
			6 x 6	10 a-c	15		100		$2000
Dept. Store	Press	1940	6 x 5	15 a-c	25	75	275	Suc. unloading	$1500
Dept. Store	Press	1941	6 x 5	15 a-c	30	75	275	Suc. unloading	$1500
Spa	Laundry	1944	6 x 5	15 a-c	15	75	250	Suc. valve unloading with steam	$1600
Hotel	Laundry	1945	9 x 9	40 a-c	25	90	935	Suc. unloading with air	$3600

HOW YOU CAN SIMPLIFY YOUR 1946 STEEL VALVE PROCUREMENT PROBLEMS

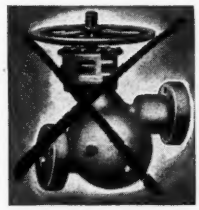
An Annual Report to Steel Valve Users

THROUGHOUT the war, steel valves were among the most critical of all common components and though the industry's capacity was expanded substantially, many types of steel valves are, and will continue for some months to be, very tight.

The time lag on deliveries depends upon size and type of valves. Production of large, cast steel valves is running behind schedule because of uncertain foundry production and labor conditions. Too, there is a substantial pent-up demand in certain civilian industries which were unable, during wartime, to obtain the high priorities which were always required for steel valves.

HELP YOURSELF

You can simplify your 1946 steel valve procurement in several ways:



1. Avoid special designs. Standard valves are in continual production, whereas "specials" usually require engineering department time, extra pattern or die work, and special handling in the forge shop or foundry.

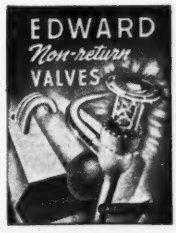
2. Anticipate your requirements and place orders early. While we are able to supply many sizes and types of standard valves out of stock shipment now, demands are still so heavy that single orders may nearly wipe out the stock in one size or pressure class.

ORDER CURRENT DESIGNS

You can also simplify your purchasing problem if you order from the most recent catalogs. During the past year, we have issued three new catalog sections which should be in your Edward catalog file. We suggest that you write us for copies if you have not already received these catalogs:

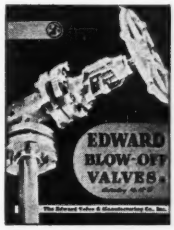
Catalog 12-B
Edward
Non-Return
Valves

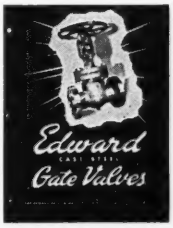
Dimensions, cross-section illustrations and descriptions for cast and forged steel non-return valves in 300 to 2500 lb sp classes. Maintenance hints, pressure drop data, pressure-temperature tables and other useful data are included.



Catalog 12-D
Edward
Blow-Off
Valves

Design detail for Edward blow-off valves with installation and operating suggestions.





Catalog 12-E
Edward
Gate Valves

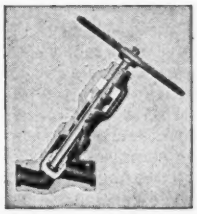
Cast steel, for service from 150 to 3600 lb. Description and illustrations of the new, basically different Edward gate valve line.

NEW VALVE DEVELOPMENT

During the past year, Edward has continued its program of design improvements. Among the dozens of new developments introduced during the year, were these:

Redesigned bodies for further lowering the already remarkably low pressure drop through Edward non-return and stop valves.

The new Intex Univalve, a patented welded bonnet valve with an integral hard-faced seat, a hard-faced disk, bolted gland, bronze yoke bushing, one-piece bonnet and exceptionally low pressure drop.



Redesign of forged steel bodies of the Edward inclined stem type to reduce pressure drop through small globe valves to the point where it is comparable to flow through gate valves.

A new type of throttling valve, especially built for excessively severe service.

Pressure sealed bonnet connections for high temperature, high pressure valves.

We will be glad to give you detailed information on any of these developments which are of particular interest to you if you will drop us a line.

FUTURE PROJECTS

Edward laboratories and engineering departments have the largest backlog of new development projects in the company's history. In metals, we are working—with considerable success to date—on materials for extremely high and extremely low temperatures, so that we will be ready with valves for the several new technological processes coming which will require very high or very low operating conditions. We are continuing our extensive work in flow and pressure drop testing, incorporating our discoveries in modified designs as fast as they are proved. We are conducting research in high temperature bolting, new types of hard facing, new welding techniques, and so on. To simply list current projects takes several pages of close typing.

A NEW NAME

January 1, 1946 is a significant date in the history of this Company. On that date, The Edward Valve & Manufacturing Company, Inc., becomes, simply, Edward Valves, Inc. The old name has been recognized for the pioneering work the Company has done in steel valves, dating back to the turn of the century when the first Edward valves were built. The new name, we feel, is in keeping with the Edward product and policies, developed through the years—functional, simple, direct, up-to-date.

So, from now on, we sign ourselves as, Edward Valves, Inc.

W. F. Crawford
President

EDWARD VALVES, Inc.
EAST CHICAGO, INDIANA
A Subsidiary of Rockwell Manufacturing Company

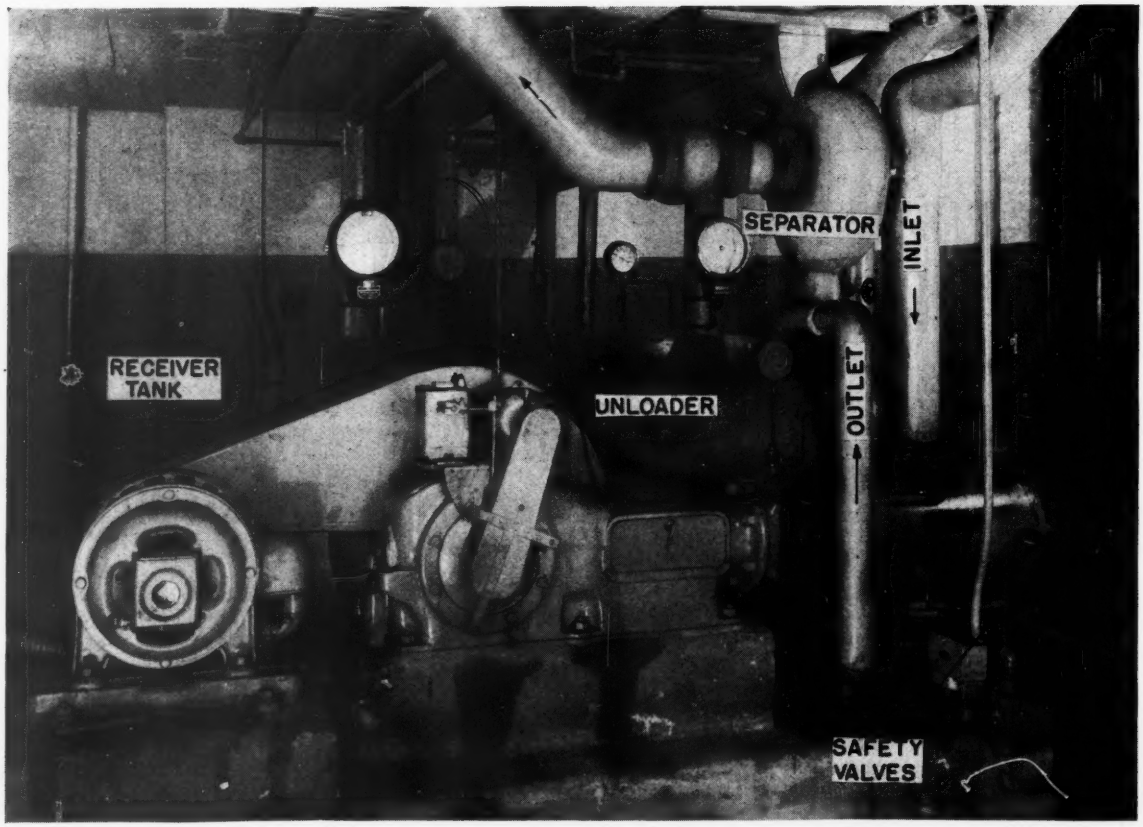


Fig. 1. View of a typical steam compressor installation

steam. The desired pressures and temperatures can be obtained by the use of steam compressors, which increase the pressure and temperature of the available steam supply. This will increase the capacity and efficiency of utilizing apparatus.

Compressor Data

The modifications required to convert an air compressor to a steam compressor usually consist of using metallic packing for the piston rod, and the application of insulation on the compressor cylinder in place of the water jacket. The steam compressor is usually motor driven although there are instances of steam-driven steam compressors.

Table I presents information concerning steam compressor installations of which the author has some knowledge. There are other installations where the steam is compressed to higher pressures than any of those listed where certain process work requires higher temperatures. It will be noted that the majority of these compressors in Table I are for club or hotel laundries where relatively small amounts of high pressure steam are required.

For any installation, it is important to select a compressor of the proper size and the actual demand for high pressure steam should be carefully determined to segregate the steam load in such a manner that only steam required for high pressure purposes is supplied by the compressor and that low pressure steam is used for all low pressure requirements.

How Install Compressor

A recommended hook-up for steam compressors is shown by Figure 2. The installation may vary somewhat according to local building regulations, and piping and accessories must be installed to suit local conditions. A steam separator on the steam inlet to the compressor is desirable to remove any moisture in the steam before it enters the compressor. The separator on the discharge side, installed to eliminate the oil from the steam, should be some distance from the compressor, as the removal of oil will be more satifactory.

The receiver serves only to a very limited extent as the storage capacity of high pressure steam, but it makes a convenient location to connect the control devices and serves as a supplementary oil separator. The pressure relief valve, with a capacity equal to the compressor output, should be installed on the discharge side of the compressor. Usually this relief valve is vented to the room so that leakage can easily be detected, but it may be piped to the outside if desirable.

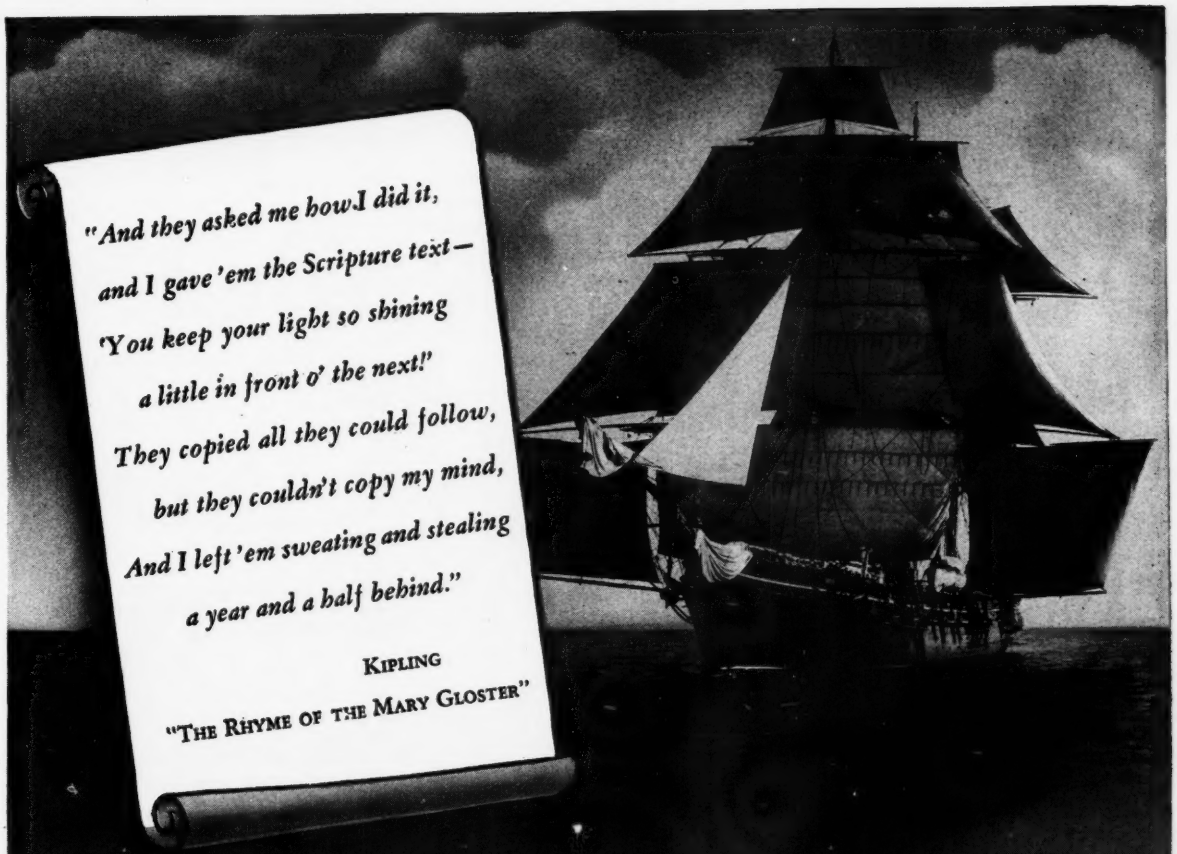
It is recommended that safety relief valves be installed on each end of the cylinder although some compressor manufacturers contend that with their type of valve there is ample protection against excess pressure.

Control of Steam Compressors

Several types of pressure control are available for steam compressors. A throttling governor on the suction to the unit is the least desirable as this increases the cost of power. Another scheme is to install a pressure relief valve on the discharge and allow the vented steam to be discharged into the suction of the unit. A more satisfactory method is to equip the compressor with suction unloading

Table II. Steam and power consumption per month for a typical steam compressor installation, based on daily readings for one week

Suction Pressure, Lb per sq in.	Receiver Pressure, Lb per sq in.	Steam Compressed, Lb	Power Used, Kw-hr	Kw-hr per M Lb Compressed
32	60-80	41,600	1320	31.7
32	50-85	40,300	1406	34.9
32	55-80	41,600	1217	29.3


"And they asked me how I did it,
and I gave 'em the Scripture text—
'You keep your light so shining
a little in front o' the next!'
They copied all they could follow,
but they couldn't copy my mind,
And I left 'em sweating and stealing
a year and a half behind."
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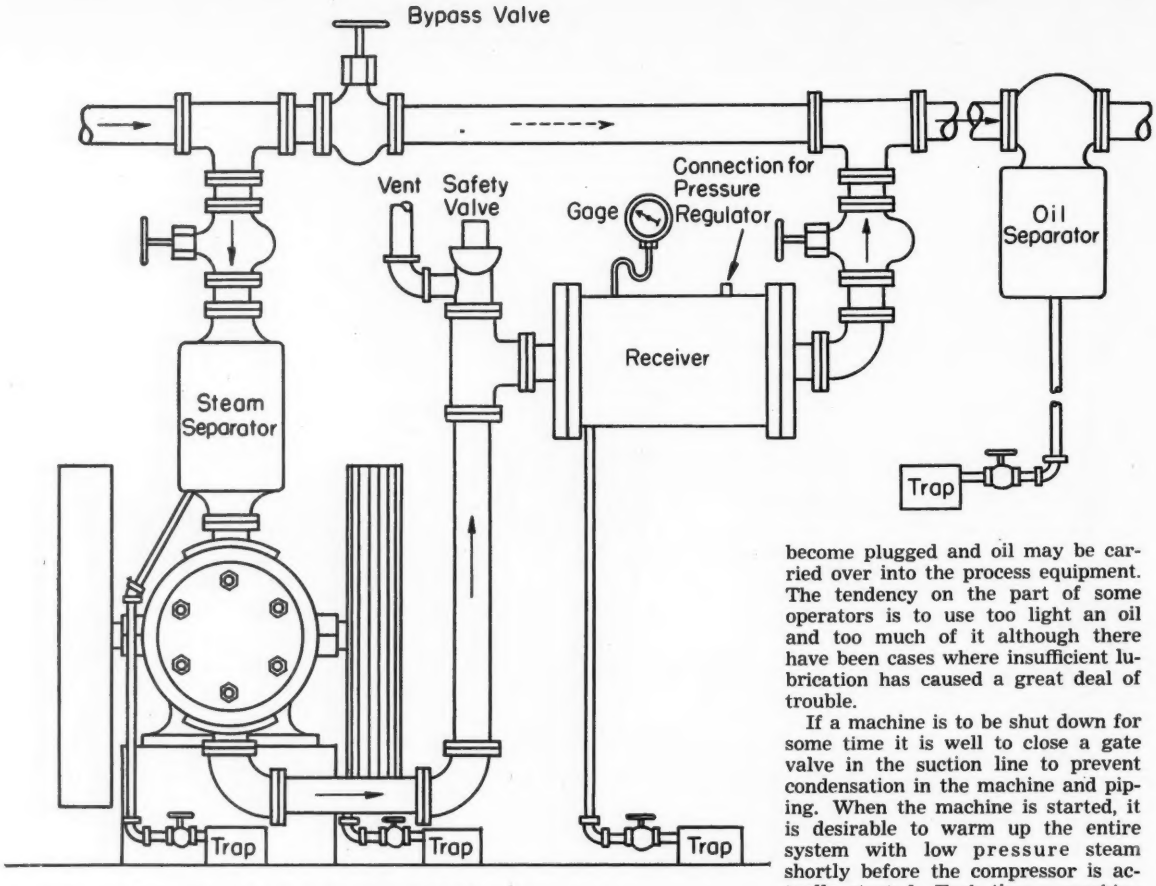

Fig. 2. Diagram showing an approved method of installing a steam compressor

valves, Fig. 1, which hold the suction valves open when the discharge pressure reaches its predetermined limit. The operating medium for the valves may be either compressed air or steam from the receiver. Caution must be observed in using air as the leakage of air through the unloading valve into the steam will result in a decrease in steam temperature.

Operating the Steam Compressor

The operation of a steam compressor is essentially the same as an air compressor with the exception of starting and stopping the machine and the supply and removal of lubricating oil. Lubrication of a steam compressor should be carefully gone into with its manufacturer. When excess oil is used steam traps may become plugged and oil may be carried over into the process equipment. The tendency on the part of some operators is to use too light an oil and too much of it although there have been cases where insufficient lubrication has caused a great deal of trouble.

If a machine is to be shut down for some time it is well to close a gate valve in the suction line to prevent condensation in the machine and piping. When the machine is started, it is desirable to warm up the entire system with low pressure steam shortly before the compressor is actually started. Each time a machine is started up, the drip traps on the high pressure side should be checked to make sure that they are operating.

The condensation from the traps on the discharge side of the compressor and adjacent to the compressor should not be connected to any condensate which is to be metered or reused in the boiler, since it contains a great deal of oil. These traps should be discharged to the sewer.

ASME in Its 66th Annual Meeting

(*Continued from Page 75*)

erties and characteristics were discussed were: combination, resin and plaster of Paris; comprey, a resinous product; foam sponge; and Neoprene.

Graphitization Research

Investigation of the phenomenon of graphitization of piping is still being carried on by the joint subcommittee of the Edison Electric Institute and the Association of Edison Illuminating Companies with the involved problems apparently still defying complete solutions. The progress made to date was summarized in a report submitted by S. L. Hoyt, R. D. Williams and A. M. Hall who are carrying on their work at Battelle Memorial Institute. It was stated that it is possible to give reasonably good answers to some of the more important questions, but it should be recognized that the exploration of a new field is likely to raise additional questions the existence of which had not been anticipated.

Results of graphitization studies were also reported by J. J. Kanter; G. V. Smith, S. H. Brambir and W. G. Benz; R. W. Emerson and M. Morrow; A. J. Smith, J. Urban and J. W. Bolton; and F. Eberle.

Oil and Gas Power

Papers in the field of oil and gas power dealt principally with the problems of aviation; several papers, however, were of direct interest to stationary power engineers. One of these was a progress report for the ASME Special Research Committee on Internal Combustion Engines presented by Martin A. Elliott and dealt with the problem of correction of measurements of power output of Diesel engines to standard atmospheric conditions.

Analyzing the internal combustion engine as a heat engine, Ralph Miller presented as his findings that, with present day materials, the output of the internal combustion engine is limited by the temperatures reached in the internal surfaces and not by lack of air to sustain combustion. A method was developed by which the output capacity of four-cycle engines may be increased by more than 100 per cent.

A list of the papers of outstanding interest to power engineers in the stationary field is included as part of this report. Copies of most of those listed may be secured from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

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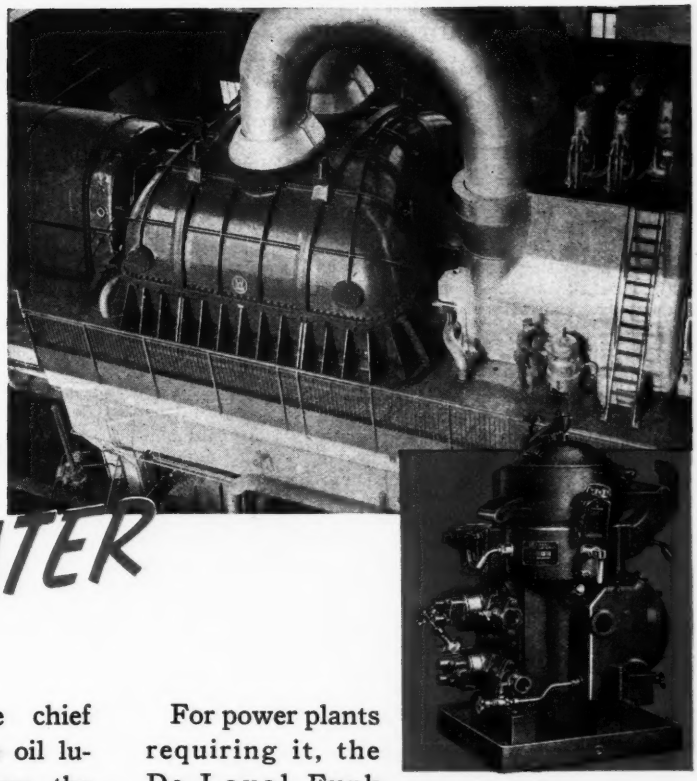

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Montaup Boiler—Operating History and Performance

(*Continued from page* 79)

Furnace Tube Temperatures

The measurement of the fire side skin temperature of furnace wall tubes is of considerable interest to boiler manufacturers and users. The data obtained at Montaup and already published show that even in a bare tube furnace and in the zone of highest flame temperature with pulverized fuel firing the hot face metal temperature with normal slag covering was only about 50 F above saturation temperature. It may be readily calculated that the heat absorption at the point of temperature measurement was only about 50,000 Btu/hr/sqft, allowing for reasonable drop at the evaporating film.

These data also show the effect of deliberately removing the slag and ash coating from a portion of the wall, thus exposing a small surface to the full radiation of the flame at a temperature approaching 3000 F. Under these conditions the skin temperature rose to a maximum value 172 F above saturation (786 F - 614 F sat. temp.), and the corresponding heat absorption rate would be about 150,000 Btu/hr/sqft, allowing for temperature gradient between inside surface and the evaporating water.

In a special study of eight tubes made in 1944, tube temperatures at various elevations were taken and the maximum tube temperature measured was 720 F.

Steam Purity

The source of make-up water and the season of the year had a very marked effect on steam conductivity leaving the high pressure boiler. There is also a seasonable variation in ammonia caused by the make-up water from the evaporators even though the make-up is only about 2 per cent. The conductivity of undegassed steam samples taken from the dry drum ahead of the final drying screens was found to be 4.23 mmho and 4.56 mmho at boiler loads of 620,000 and 650,000 lb/hr respectively. Other samples evaporated during the same week indicated that the conversion factor was 0.20 or less, so the corresponding total solids in the dry drum would be 0.85 and 0.91 ppm respectively. This would indicate that without the dry drum the purity would be equal to or better than the minimum required guarantee of 1.0 ppm which has now been established by the A.B.M.A. & A.I. The guarantee on this unit was 0.50 ppm and the screens in the dry drum remove enough moisture to bring the final results below the guarantee.

Performance

Circulating Pumps

Test data plotted in Fig. 3 and Fig. 4 show that two pumps handle about 3,200,000 lb/hr, and since the operating water content of the boiler is about 30,000 lb. (exclusive of economizer) this represents a recirculation rate of more than 100 times per hour. At 650,000 lb/hr load with one pump the water to steam ratio would be nearly three to one, a condition which should not cause any trouble during an emergency period. There were short periods early in 1943 when only one pump was in operating condition, but no outage of the boiler was ever caused by the circulating pumps. Total heat absorption of each part of the unit was very close to manufacturer's predictions except in the case of the reheater which was too conservatively designed.

Superheat Control

The automatic operation of both sets of dampers at economizer outlet results in very close regulation. As the furnace accumulates ash and the gas temperature increases, the by-pass dampers automatically open and maintain the steam temperature within ± 5 F of the desired limit. At the end of an eight-hour operating period the by-pass dampers will be 50% to 80% open, depending on the output rate and the nature of the coal. Then as the wall blowers are operated the by-pass dampers operate automatically to compensate for the effect of removing the ash from the walls and maintain the same close regulation of steam temperature during the cleaning period.

Capacity and Flexibility

The maximum peak capacity of the boiler has never been determined. The maximum demand has been 670,000 lb. per hr, but the feeders, burners, fans and circulating pumps are adequate for higher output.

At reduced pressure there is no decrease in circulation and the volumetric percentage of steam in the mixture leaving the generating tubes will increase so the average velocity in the tubes is greater. The unit is therefore very flexible as regards operation at variable pressure and the upper limit of capacity would be governed by considerations of steam purity and steam temperature rather than circulation.

The boiler has a very stable water level even under extreme operating conditions of sudden load increase or decrease. Also, on the occasion of furnace tube failures, it has not been difficult to maintain water level while reducing load and pressure in an orderly manner.

Efficiency

The contract overall efficiency with coal firing at 650,000 lb per hr output was 89.3 per cent based on coal of 14,200 Btu per lb with 2.8 per cent moisture as fired; and based on 15 per cent CO_2 in gases at economizer outlet, with 290 F gas temperature leaving air heater, 80 F entering air temperature, and with 0.60 per cent allowance for unburned combustible.

Montaup Boiler—Instruments and Control

(*Continued from page* 84)

conditions oxygen concentration recorded as "zero," expressed in parts per million, and the approximately full load concentrations of hydrogen are close to 2 ppb in the feedwater at the boiler 6 economizer entrance and below 3 ppb in the super-heated steam as delivered to the high pressure turbine. Other full load characteristics recorded by the instruments of group 2 are conductivity of steam about 1.5 micromhos as sampled, varying with the seasons, and 0.6-0.7 micromhos degassed, conductivity of chemically treated feedwater about 5 micromhos, conductivity of boiler water about 1,000 micromhos, pH value of feedwater 8.3, and pH value of boiler water 10.3.

Value and Limitations of Hydrogen Recorder

It had of course been recognized that hydrogen evolved in the feedwater system or boiler might combine to some extent with oxygen where found dissolved in the water in contact with the metal surface. A contingency overlooked was that an oxide of copper might function in the system as a source of oxygen. The practical importance of chemical action of that sort was brought strongly to attention by the October 26, 1945, furnace tube failures taking place without marked increase in recorded rate of hydrogen evolution in the boiler.

One of the low pressure turbine stage heaters, temporarly operated as an evaporator condenser, had been returned to this vapor condensing service immediately following installation of 468 new tubes of Admiralty alloy. Apparently, the copper carried into the feedwater system in oxidized form from the corrosion of the new Admiralty alloy tubes was sufficient to cause practically complete disposal of the hydrogen evolved from the overheating of the boiler tubes.

The rate of hydrogen evolution which occurs during the first few weeks of operation of an acid cleaned boiler may be so high as to mask any increase in rate of hydrogen evolution which might result in the boiler from other than extreme contamination or actual overheating.

Notwithstanding such interfering factors as mentioned, hydrogen evolution in a boiler gives the best known indication of corrosion or solution of the boiler metal and the measurement of the rate of this evolution affords the only feasible basis for judging the extent of corrosion taking place while the boiler is in operation. Means for minimizing the effects of interfering factors are being studied.

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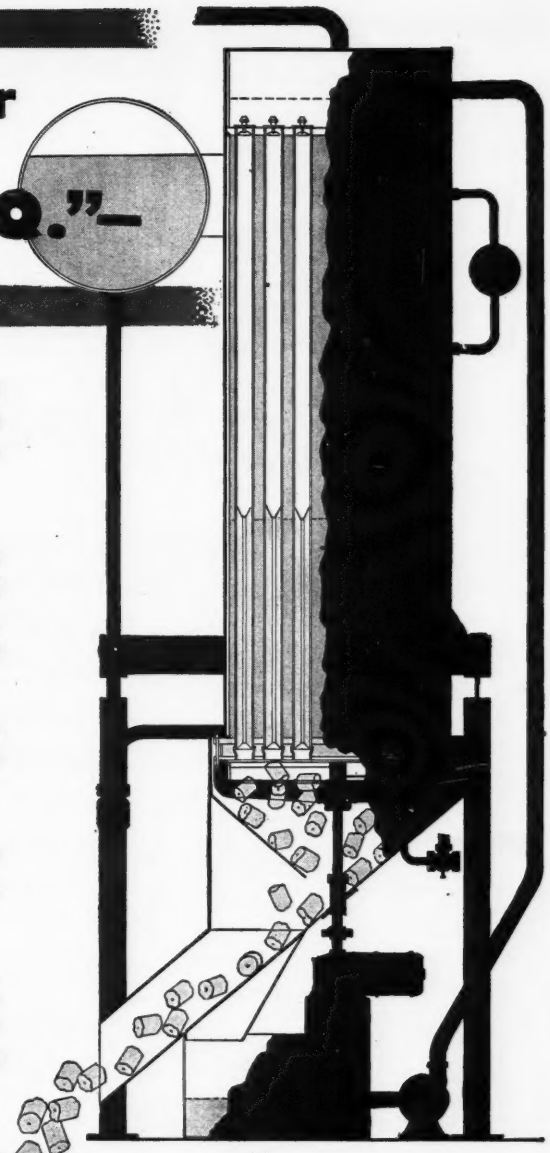

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2. It takes 40 to 50 hours to freeze tank ice. How many hours are required for a complete cycle of freezing, thawing and evacuation of Vogtice?

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4. A Vogtice making machine of 50 tons capacity requires one, two, or four operators?

5. Cutting and crushing wastes of 15% to 35% are common to ordinary ice sizing systems. Vogtice machines have what per cent of waste?

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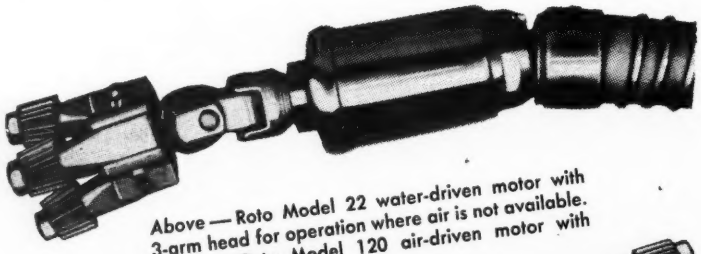

Above — Roto Model 22 water-driven motor with 3-arm head for operation where air is not available.
Below — Roto Model 120 air-driven motor with 3-arm head.

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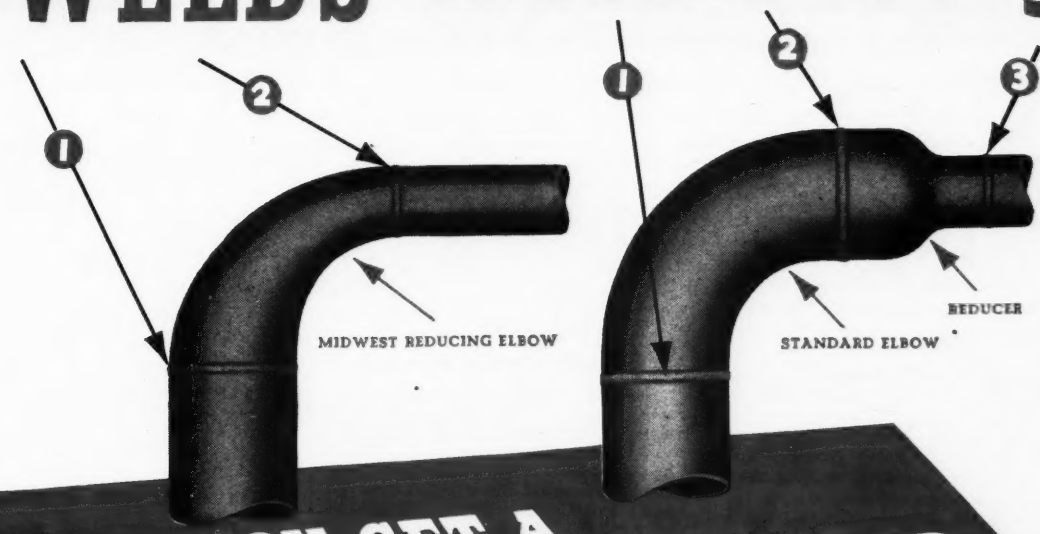

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MARINE AND POWER EDITION

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Prepared by Bridgeport Brass Company "Bridgeport" BRASS CO. *Headquarters for BRASS, BRONZE, and COPPER*

Looking Ahead For 1946

Indications are that 1946 will be a busy year for power plants because of the great amount of modernization and new construction planned. The continued increase in the use of electricity in the fields of transportation, communications, housing and many branches of industry keeps the power consumption curve generally upward. It follows therefore, that as electricity continues to find more uses in industry and new applications in the home and on the farm, many power plants must increase their capacities either by modernizing or by adding new equipment.

Planning Future Growth

What has been learned from the war? During those difficult years, power plant operators were called upon to produce more and more electric power despite the added burdens of inadequate manpower, fuel shortages, and material restrictions. The fact that power plants came through with flying colors can be credited to farsighted management policies which made possible the extension of capacities considerably beyond normal, and the ingenuity of the engineer which enabled plants to operate despite overloaded equipment badly in need of replacement.

Those plants which had good condenser tubing made from the most corrosion resistant alloys were in a very favorable position because they could stand overloading. On the other hand, plants with poor, worn out condenser tubes had to nurse them along. Restrictions in copper and brass for the war effort therefore placed a greater hardship on plants which could not take advantage of the more corrosion resisting alloys.

Trend Toward Better Alloys

Since the type of condenser tubes used has a very important bearing on the efficiency and operating expense of power plants, the trend is toward the use of more corrosion-resistant alloys. There are many factors which have an adverse effect on the life of condenser tubing—faster steam condensation which requires high circulating water velocities; and increasing contamination of water by chemical and industrial wastes. Many operators are studying these conditions as they apply to their power plants.

They are carefully observing the life of test installations of various condenser tube alloys in order to learn which one is best suited to their particular circulating water and operating conditions.

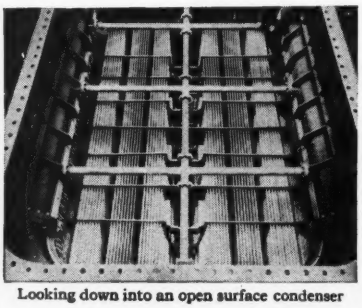
Increased Efficiency Necessary

There are additional factors which management must take into consideration when planning for the extension and modernization of power producing facilities. The cost of labor is rising and there seems to be little prospect of materials selling for lower prices. Consequently, increased efficiency will go a long way toward offsetting these conditions.

One of the most important factors in improving the efficiency of power plants is the use of modern corrosion-resistant condenser tube alloys. Operators can choose from a number of fine alloys which have been developed through extensive research in the field of corrosion as well as along metallurgical lines. A large number of field and service tests have been carried out in cooperation with power plant operators by our Technical Service Department made up of laboratory-trained men, some of whom specialize in corrosion. These tests help determine what results may be expected of the various condenser tube alloys under actual operating conditions. Such programs bring beneficial results both to producers and users of tubing. The trend is toward greater cooperation between the manufacturers and operators.

Less Frequent Retubing

Metallurgical research has accomplished a great deal in developing alloys to resist dezincification, impingement, general thinning and other types of corrosion. Improved equipment and processing techniques have brought forth fine corrosion-resistant alloys, such as Duronze IV (aluminum brass), cupro nickel and cuzinal (aluminum brass) which stand up longer under corrosive water conditions and high water velocities.



Looking down into an open surface condenser

From the standpoint of economics it may be cheaper in the long run to use a more expensive corrosion resisting alloy. This will bring down the condenser-service-hour-cost because of its longer life—less frequent retubing and lower maintenance.

Much technical information on corrosion, characteristics of various alloys, specification data, etc., is contained in Bridgeport's 112-page Condenser Tube Manual. Write for your copy on company stationery.

Corrosion and Biofouling of Copper-Base Alloys in Sea Water

Engineers and metallurgists interested in the corrosion resistance of copper-base alloys in sea water, will find much valuable data in a paper prepared by C. L. Bulow, Research Chemist of Bridgeport Brass Company. This appeared in the Transactions of the Electrochemical Society 1945, 87, 319.

During June, 1942, plans were laid for making an extensive sea water corrosion test. It was hoped that information would be obtained concerning thirty copper-base alloys which could be used as standard reference values in connection with their corrosion resistance in clean sea water. Further consideration of the problems involved in such an extensive test led to the use of the excellent facilities available at the International Nickel Company's sea water corrosion test station at the Ethyl-Dow Chemical Company, Kure Beach, N. C. This paper is a preliminary report covering the results obtained during the first year of testing at this site.

A total of 240 test pieces of copper alloys, of widely varied composition, were exposed to clean flowing sea water (60 to 90 cm./sec.) for periods of six and twelve months, during which the water temperature ranged between 2 deg. and 30 deg. C.

Alloys tested include Muntz Metal, high brass, cartridge brass, commercial bronze, various coppers, admiralty, aluminum brass, naval brass, manganese bronze, phosphor bronze, silicon bronzes, aluminum bronzes and cupro nickels. Corrosion rates of the different alloys are discussed and data presented on loss in tensile strength and weight, impingement corrosion as well as general surface pitting. There are also data on the effect of alloying elements such as arsenic, aluminum and iron. There are 19 tables, 8 sets of curves as well as descriptive material and photographs.

We shall be glad to supply reprints of this paper. Kindly address your request on company stationery.

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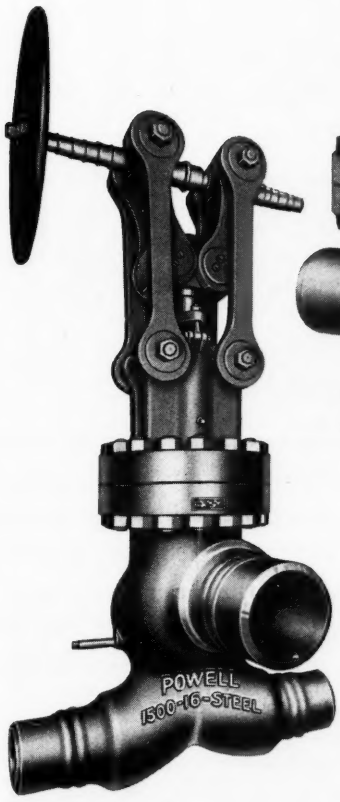
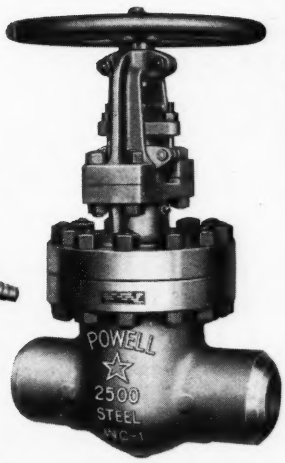
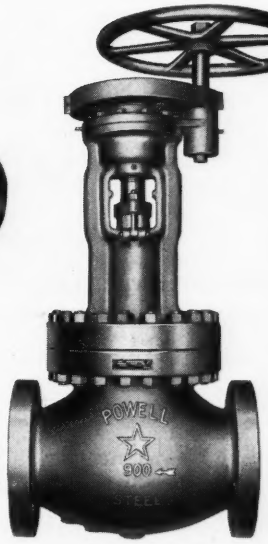


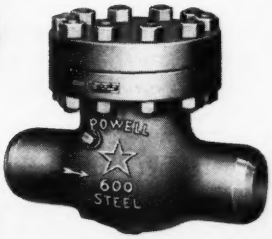
Class 1500-pound Cast Steel, Toggle Operated Non-return Angle Valve with welding ends. Has 16" outlet and two 12" inlets. Because of special streamline designing, the pressure drop through the valve is reduced to a minimum.



Class 2500-pound Cast Steel Welding End O. S. & Y. Gate Valve.



Class 900-pound Flanged End Cast Steel Non-return Globe Valve. Spur gear operated.



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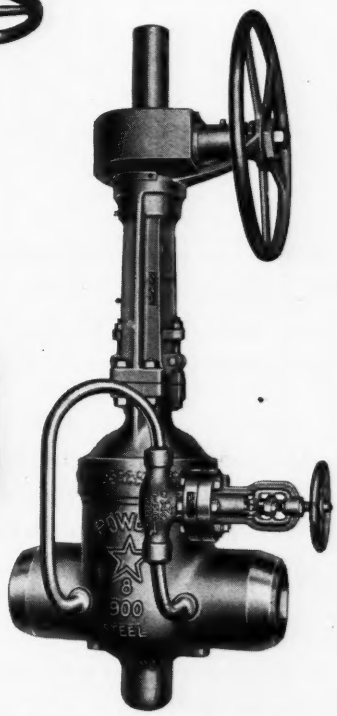

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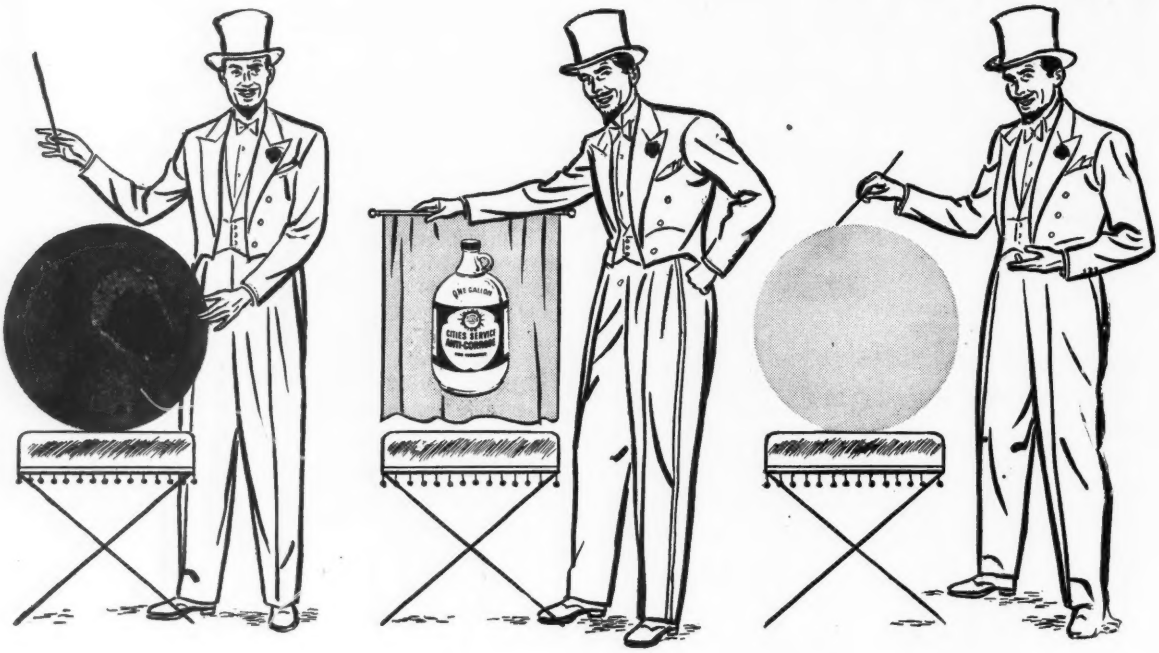
POWELL VALVES

Now you see it_Now you don't



What you see is a close-up of rust formation, Industry's $100,000,000 annual toll. What you *don't* see is its quick elimination with CITIES SERVICE RUST REMOVER.

Converting your rust liability into profit isn't magic . . . it's made possible by Cities Service Rust Remover—an effective product—proved in scores of industrial plants. Easy to apply—inexpensive—can be used over and over again with little waste.

Once you have cleared your machined parts of rust, the next step is to protect them against further rusting. Then you will want one of the Cities Service Anti-Corrodes to provide an impenetrable film that really protects. One of our Lubrication Engineers will be glad to help you select the right one. Write, wire or phone our nearest office or . . .

Cities Service Oil Co.
Room 586, 70 Pine Street, New York 5, N. Y.

Gentlemen: Please send me full information on Cities Service Rust Prevention Plan.

Name.....

Title.....

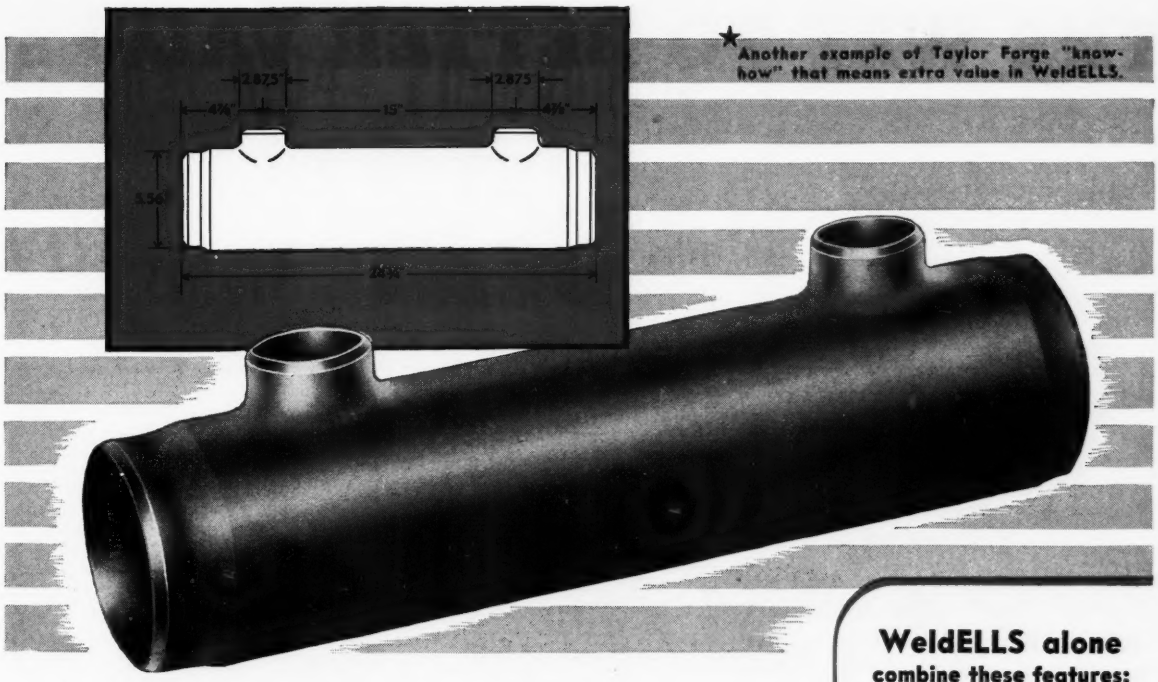
Company.....

Address.....

City.....State.....

MAIL THIS COUPON TODAY

CITIES SERVICE OILS
ONCE-ALWAYS



★ Another example of Taylor Forge "know-how" that means extra value in WeldELLS.

TEE FOR TWO.....

Taylor Forge arrangement—

★ *Of course two tees with a nipple welded between them could be made to provide an assembly with the same dimensions as this special "tandem outlet tee." However, a rigid set of conditions demanded this seamless one-piece fitting. From there on it was the old familiar story: "This is a tough one—one for Taylor Forge."*

YES, you've heard the story before: A tough one is one for Taylor Forge! It's really no wonder so many of the people who come to Taylor Forge for the unusual, and often very difficult jobs, are equally careful to see that their needs for standard welding fittings are always supplied by Taylor Forge.

They *should* be equally careful, because the very same factors that have built the Taylor reputation for licking the tough ones, provide many extra values that are found only in WeldELLS and other Taylor Forge fittings for pipe welding.

In the sense of knowledge and experience, WeldELLS, too, are "special." Special steps are necessary to achieve uniform strength through selective distribution of extra metal where stresses are greatest. Special truing operations give WeldELLS their remarkable dimensional accuracy. Special processes account for the tangents and many other features of WeldELLS.

In fact, you will find Taylor Forge know-how reflected in every one of the features listed opposite. Check the list and we believe you will agree that

WeldELLS alone combine these features:

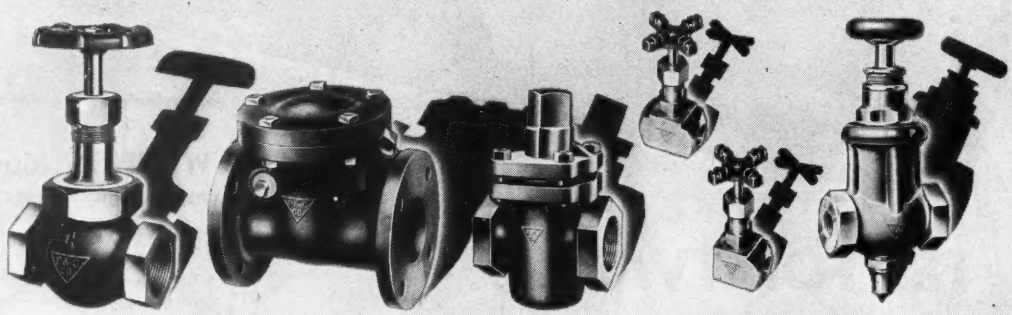
- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

WeldELLS have everything

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago P.O. Box 485
New York Office: 50 Church Street • Philadelphia Office: Broad Street Station Bldg.

THE WAY TO BETTER VALVES

READING-PRATT & CADY



Globe Valve—with renewable slip-on disc—patented by Pratt & Cady.

Swing Check—patented by Pratt & Cady.

Asbestos-Packed Cock—introduced in U. S. by Pratt & Cady.

Bar Stock Globe and Angle Valves—originated by Reading-Pratt & Cady.

Piston Internal Pilot Controlled Automatic Regulating Valve—originated by d'Este.

During the last century, when the now ordinary valve types were being originated and patented, Pratt and Cady contributed, among others, such items as the slip-on disc for globe valves and the swing type of check valves. d'Este originated the piston internal pilot controlled regulator. This activity continuing to present times is illustrated by the bar stock valves originated by Reading-Pratt and Cady.

And when early in this century, a need developed for a valve material other than brass and iron and the available steel castings proved inadequate, Reading specialized and pioneered in the development of the art of producing steel pressure castings. That development has been continuous. particularly as the requirement for alloy steels has appeared and increased.

The way to better valves is to continue development.

Reading Cast Steel Valves and Fittings • Pratt & Cady Brass and Iron Valves
d'Este Automatic Regulating Valves • Helicoid Pressure Gages

READING-PRATT & CADY DISTRIBUTORS IN PRINCIPAL CITIES

ACCO

Reading, Pa. • Atlanta • Chicago • Denver • Detroit • Houston • Los Angeles • New York • Philadelphia • Pittsburgh • San Francisco • Bridgeport, Conn.

READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

What 0.04% Phosphorus Does To Your Dezincification Problem

Plain Admiralty Metal has almost all the properties for successful condenser and heat exchanger tube service that are needed to meet many power plant and oil refinery applications . . . but it has one weakness — fair to poor resistance to dezincification.

Under certain conditions, its brass content is gradually replaced by a spongy, porous copper deposit, locally (plug type) or uniformly over the tube (layer type).

To overcome this problem . . . and still retain the high corrosion resistance of plain Admiralty . . . Scovill *Service in Metals* developed Phosphorized Admiralty*. This is the alloy that Scovill engineers are recommending for many types of power plant and oil refinery service where dezincification of plain Admiralty has been observed or anticipated.

Many Times Greater Life

By inhibiting dezincification, Phosphorized Admiralty offers much longer service life. This improvement is brought about by a very slight change in the alloy composition — the addition of approximately 0.04% phosphorus. There is no appreciable difference in the structure or mechanical properties between regular and Phosphorized Admiralty as shown by the photomicrographs and graph at the right. There is no impairment of the metallurgical, physical and otherwise excellent corrosion-resistant properties.

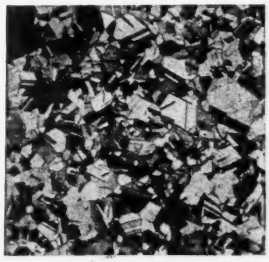
Experience of Scovill customers has shown that in cases where dezincification has been troublesome, a change to Phosphorized Admiralty extends service life.

*"Phosphorized Admiralty Tubes" for condenser and heat exchanger service are covered by patent 2,224,095 and can be legally supplied only by Scovill Manufacturing Company, the owner of this patent.

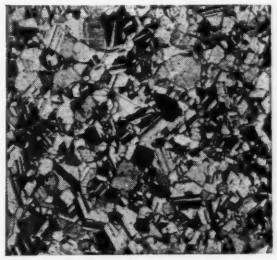
Other Scovill Services

Service in Metals, which includes the development of new alloys to meet changing service conditions and also individual study of specific customers' problems, is one of three Scovill services, well-known throughout Industry. *Service in Men* provides specialized advice on tube problems, installation aids and "follow-up" services. *Service in Manuals* offers valuable literature on condenser and heat exchanger tubes. For a copy of our Condenser Tube Booklet, address Scovill Manufacturing Company, 17 Mill Street, Waterbury 91, Conn.

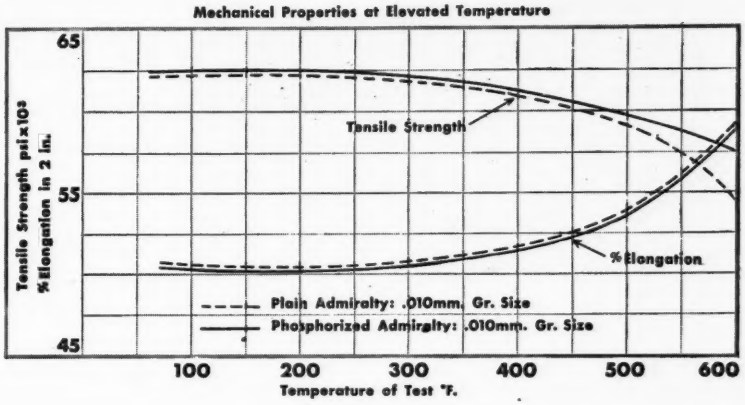
Top: Plain Admiralty.
Bottom: Phosphorized Admiralty.



75 x magnification.
Average grain size .035 min.



Mechanical Properties at Elevated Temperature



Plain Admiralty		Phosphorized Admiralty	
Copper	70.0 — 73.0	Copper	70.0 — 73.0
Tin	0.90 — 1.20	Tin	0.90 — 1.20
Lead	0.075 max.	Lead	0.075 max.
Iron	0.06	Iron	0.06
Phosphorus		Phosphorus	0.10 max.
Zinc	remainder	Zinc	remainder

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.

SCOVILL CONDENSER TUBES

ONE PRODUCT . . . THREE SERVICES

Service in Manuals . . . Service in Metals . . . Service in Men

- **RELIABILITY**
- **STRENGTH**
- **ECONOMY**
- **SAFETY**

. . . characteristics of every KENNEDY *valve*

Kennedy Valves are reliable because of their simple, sturdy and effective operating mechanisms. Many of these mechanisms were originated by Kennedy, and have proven their effectiveness in thousands of installations.

These valves are economical because of their durability which has been demonstrated by decades of service in many installations without maintenance expense.

Their generous proportions of all parts, together with high-quality, high-tensile-strength metal, assure ample strength and complete safety. You are always safe with Kennedy "Extra Value" Valves.

THE KENNEDY VALVE MFG. CO.
ELMIRA • NEW YORK

KENNEDY *valves . . . pipe fittings . . . fire hydrants*

THE MEANING OF THE OTIS TRADEMARK

To the millions of daily passengers on Otis elevators and escalators, the Otis trademark or name-plate means safe, convenient, energy-saving transportation.

To thousands of building owners and managers, the Otis trademark means the utmost in safe, efficient, economical elevator and escalator operation.

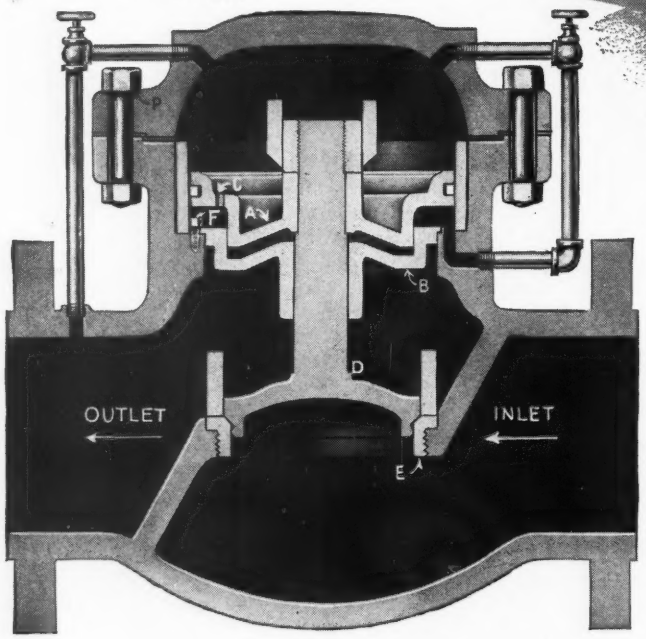
To Architects and Engineers, "Otis" means prompt, authoritative cooperation from any one of 245 local offices organized to render service based on the cumulative experience of the Otis Elevator Company.

For the finest in vertical transportation tomorrow, call your Otis representative today.

OTIS ELEVATOR COMPANY

Offices in all principal cities

Engineered PROTECTION FOR HIGH PRESSURE BOILER FEED LINES



GOLDEN-ANDERSON HYDRAULIC *Double-Cushioned* CHECK VALVES

Look to Golden-Anderson Valves for maximum *engineered safety and protection* in your boiler room.

This valve is an excellent example of the outstanding engineering built in every Golden-Anderson Valve. Designed for high pressure boiler feed lines, the double cushioning feature prevents any shock or jar in sudden valve closure. Needle valve control allows close adjustment to regulate the operating speed for *any* operating condition. Also available with manual handwheel control, in angle or globe patterns, sizes 2½" to 14"

Other GOLDEN-ANDERSON Automatic Valves

- Non-Return Valves
- Throttle and Automatic Engine Stop Valves
- Emergency Trip Valves
- Pressure Reducing Valves
- Altitude Control Valves
- Float Operated Control Valves
- Coke Quenching Valves
- and many other types for safe, dependable flow control.

Write for descriptive technical catalog!

GA

GOLDEN-ANDERSON VALVE Specialty Company

FULTON BUILDING • PITTSBURGH 22, PA.

Learn the story behind this damage

Cavitation-erosion ruined these blades. Especially designed to improve pump efficiency, this impeller was ruined by cavitation in less than four weeks. But the design was not abandoned. The eroded impeller was replaced with one made of a nickel alloy — "S" Monel. At last check, it was still in service after 2½ years — over a 3000% improvement!

A 5 MINUTE QUESTION AND ANSWER DIGEST ON CAVITATION-EROSION

THE PROBLEM

Q. What is meant by cavitation-erosion?

A. Cavitation-erosion (or simply "Cavitation") is the type of erosion caused by collapse of tiny bubbles in a liquid, with consequent hammering of the liquid against the metallic surface.

Q. Where may cavitation be encountered?

A. The inertia of a rapidly-moving liquid makes it tend to continue in a given direction rather than to follow the contours of the metallic surface over which it is flowing. This may create voids. The rush to fill them causes the cavitation. In power plants, for example, it is a particularly destructive phenomenon.

Q. Are these voids a complete vacuum?

A. No, the space is filled with vapor from the liquid and with dissolved gases that may be present.

Q. What causes the damage?

A. When the voids collapse, there results a pounding by the fluid comparable to the destructive force of tiny bullets impinging against the metallic surface. With thousands of voids collapsing every minute, the cumulative result is powerful enough to cause deformation and fatigue, and to remove films which might inhibit corrosion.

Q. How are cavitation and corrosion related?

A. Corrosion intensifies cavitation; and cavitation accelerates corrosion. Thus, a self-sustaining chain of destruction exists.

Q. How does corrosion intensify cavitation?

A. The roughened surface of a corroded metal affords greater opportunity for the formation and the collapse of voids.

Q. How does cavitation accelerate corrosion?

A. With many metals the initial corrosion rate is very rapid. However, the speed of the attack usually decreases due to the formation of protective films of the corrosion products. If these protective films are removed by cavitation, corrosion proceeds at an abnormal rate. *That is why use of corrosion-resisting metals and alloys is so important!*

THE REMEDY

Q. What important factors govern control of cavitation?

A. Laboratory and field studies indicate that the most important factors are:—

1. Proper design.
2. Resistance to corrosion fatigue.
3. Resistance to corrosion and freedom from pitting.
4. Tenacity of protective films, and speed of new film formation.
5. Strength, hardness, and ability of a metal to withstand over-stressing and to distribute locally-applied stresses.
6. Susceptibility to strain hardening.
7. Uniformity of grain structure.

Q. Why is design so important?

A. Poor design (inadequate streamlining) has proved to be the leading single cause of cavitation. And, its effect is intensified by a high velocity liquid flow.

Reprints of this advertisement are available upon request from The International Nickel Company, Inc.

Q. Doesn't this all boil down to developing the best design and selecting the right metal?

A. Yes! Both are very important and really interdependent. Sometimes a change in design will reduce cavitation. Sometimes, as in the impeller in the picture, the same design in a different metal will provide the remedy. *Consider both!*

Q. Design can be guided by skill and experience, but how can one be guided in selecting the right metal?

A. *Past performance!* Laboratory tests and field use have for years indicated that a group of high-nickel alloys should be considered wherever cavitation-erosion is a possibility.

Q. What is this group?

A. The corrosion-resisting INCO Nickel Alloys — nickel, Monel, "K" Monel, "H" Monel and "S" Monel. Their resistance to cavitation has been amply demonstrated by their successful use to replace other metals in high-speed propellers, pump impellers, hydraulic valves, agitators and in similar parts.

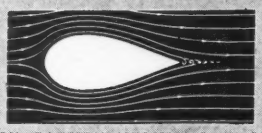
Q. Can INCO Nickel Alloys be used to build up parts that have already suffered cavitation-erosion?

A. Yes, and this ability is a big help on many repair jobs. For example, deposition of Monel or "K" Monel by arc-welding is an excellent way to build up eroded steel parts.

Q. How can more help be obtained on combating cavitation-erosion?

A. The International Nickel Company has made a special study of cavitation. If you have a problem involving this type of erosion, send full details of the application to: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

YOU SAVE MONEY
All Along the Line . . .
OVER YEARS OF SERVICE



THIS FLOW PATTERN MEANS NO TURBULENCE
The Streamlined form of the inner valve produces the flow pattern shown above which makes for maximum capacity when it is needed most and permits accurate pressure control under toughest working conditions.

"Cheap in cost in the long run" is the way they describe this CASH STANDARD "1000"—the valve with the straight line flow that gives you close delivery pressure control—accurate regulation, and greater capacity. You save money all along the line over years of service because of smooth operation and continuous performance. You have no production stoppages or product spoilage due to valve inefficiencies and there's practically no maintenance required. "Put the '1000' on the line and forget it" is another general expression of users. Investigate now and see why you can cut valve cost expenditures and at the same time get "tops" in performance.

Bulletin 962

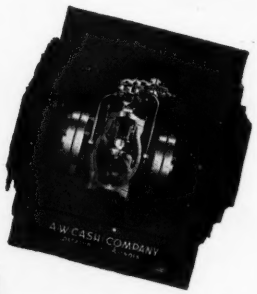
features the CASH STANDARD Streamlined Type 1000 Pressure Reducing Valve—illustrates the streamlined construction and tells why you get exceptionally long, trouble-free, low-cost performance. Points out why you get no turbulence and therefore can meet peak demand at all times. Explains why straightline flow gives you maximum capacity, close delivery pressure control, and tight closure.

CASH STANDARD CONTROLS.. VALVES

A. W. CASH COMPANY
DECATUR, ILLINOIS

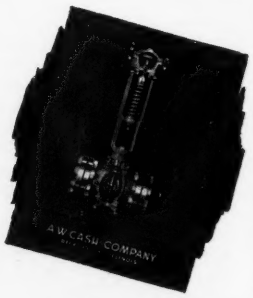
BULLETINS AVAILABLE ON OTHER CASH STANDARD VALVES

Send for them



BULLETIN 966—features the CASH STANDARD Self-Contained, Pilot Operated Type 10 Pressure Reducing and Regulating Valve for use with water or air; with any gas or oil that is non-corrosive; and with refrigerating fluids such as Ammonia and Freon. Many interesting particulars explained such as how valve works, tight seating, large capacity, no waste, no water hammer or chatter.

BULLETIN 956—features the CASH STANDARD Type 4030 Back Pressure Valve—designed to automatically maintain a constant pressure in the evaporator corresponding to a constant temperature desired. Shows an Ammonia and Freon Gas Capacity Chart based on ABSOLUTE pressures.



BULLETIN 969—features the CASH STANDARD Series 35 Constant Pressure Pump Governors—direct-operated and pilot-operated which automatically control steam-driven pumps to maintain a constant pump discharge pressure (or constant vacuum on vacuum pumps). Tells about their use with reciprocating pumps, turbine-driven pumps and compressors; including compressors for refrigeration use. Has two pages of typical installations.

FAIRBANKS-MORSE DIESELS

Four-Time Winner

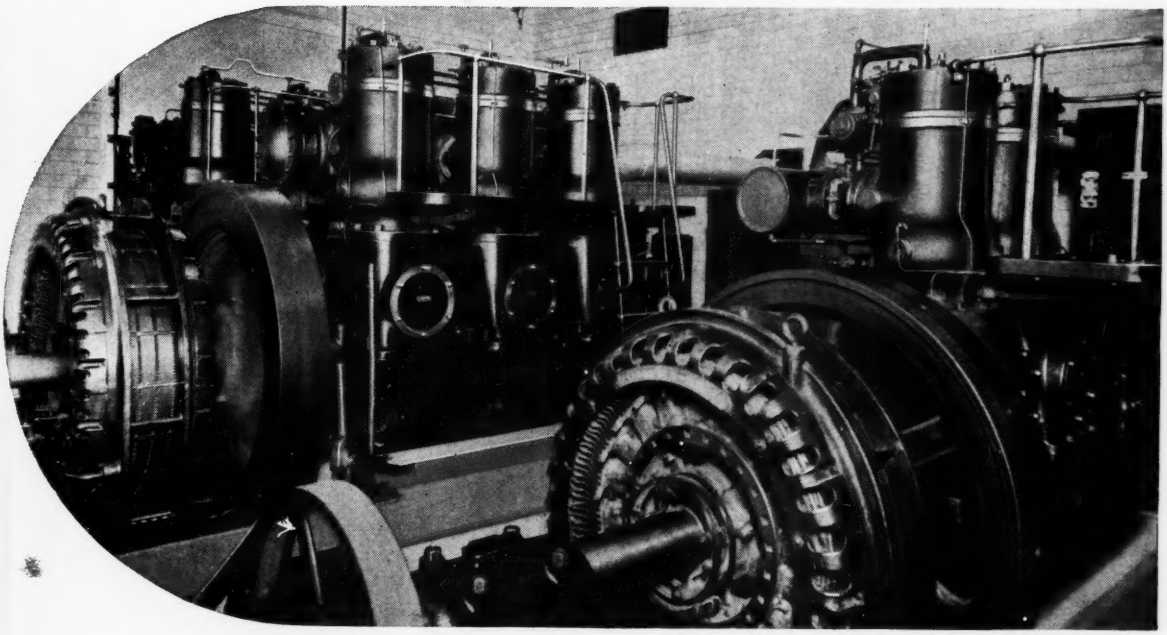
with Nylen Products

Because of the excellent performance and low operating and maintenance costs of their first Fairbanks-Morse Diesel, the Nylen Products Company, St. Joseph, Michigan, subsequently met increased power needs by installing three more engines of the same make.

Such repeat order records are anything but unusual at Fairbanks-Morse. During one typical prewar 16-month period, 80% (by horsepower) of all Fairbanks-Morse Diesels sold were repeat orders!

When you need more power, remember this—hundreds of users say *with repeat orders* that Fairbanks-Morse Diesels excel in dependability and economy.

Fairbanks, Morse & Co., Fairbanks-Morse Building, Chicago 5, Illinois.



Fairbanks-Morse

A name worth remembering

DIESEL LOCOMOTIVES • DIESEL ENGINES • GENERATORS • MOTORS • PUMPS • SCALES
MAGNETOS • STOKERS • RAILROAD MOTOR CARS AND STANDPIPES • FARM EQUIPMENT

LOOK OUT FOR SOOTY!

Sooty will squander many dollars for you unless you stop him

ALKEN CERTIFIED SOOT-OFF is the triumphant conqueror of that wasteful rascal, soot, and his close relative, fire scale. The use of **ALKEN CERTIFIED SOOT-OFF** eliminates from the tubes 70% of all soot, fire scale and gum residue, due to the burning of oil or coal.

ALKEN CERTIFIED SOOT-OFF contains no ingredients which will harmfully affect metal, cement or fire brick . . . cannot burn explosively . . . when heated does not give off gases harmful to animal or plant life . . . reduces the necessity for shut-downs . . . removes soot, carbon and fire scale that cannot be readily reached by mechanical equipment.

Take advantage of our "personalized service," which means that a written survey of your boiler operation will be submitted to our Engineering Department before any treatment is recommended. After careful study, the formula best suited for your needs is sent to you.

Illustrated booklet sent free upon request.

For "top" boiler efficiency, use

ALKEN CERTIFIED SOOT-OFF SOOT REMOVER
Reg. U. S. Pat. Off.

ALKEN-MURRAY
CORPORATION
1841 BROADWAY, Dept. PP • NEW YORK 23, N. Y.

ALKEN CERTIFIED PRODUCTS: WATER TREATMENTS · SOOT REMOVERS · SLUDGE REMOVERS

75% ARE "Flexitallic" GASKET EQUIPPED!

REG U S PAT OFFICE

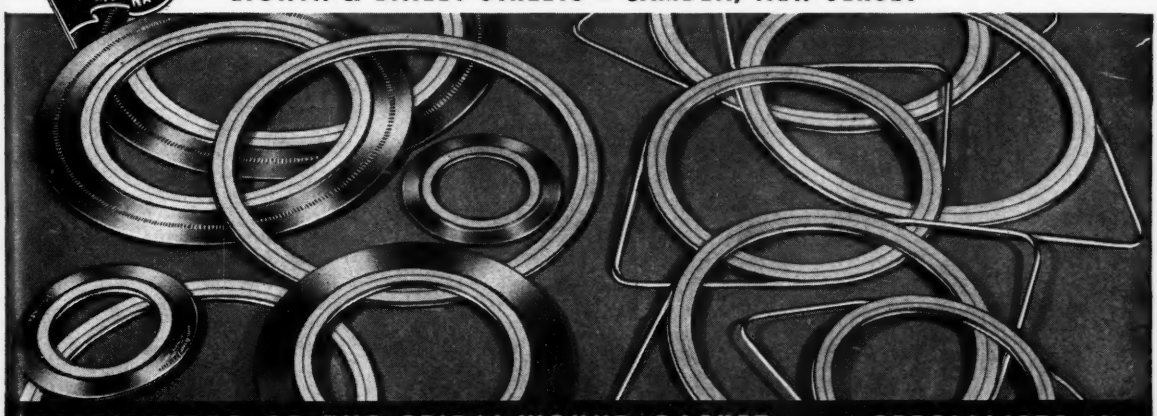
With the end of the war, probably 75% of all combat vessels and an extremely high percentage of maritime craft were equipped with Flexitallic — the original — Spiral-Wound Gaskets. Figures such as these speak plainer than words in emphasizing Flexitallic superiority and industry-wide engineering acceptance!

Flexitallic Gaskets will not let you down when the going is rough. Their resilient construction compensates for even the most violent pressure surges, temperature changes, and vibration stresses. They'll stand the gaff—and come back asking for more. In addition, they're easier to install, minimize laborious hand finishing of seating surfaces and eliminate complicated gauging of bolting tension. Write for catalog.

ARMY E NAVY

FLEXITALLIC GASKET COMPANY

EIGHTH & BAILEY STREETS • CAMDEN, NEW JERSEY



ORIGINATORS OF THE SPIRAL-WOUND GASKET . . . SPECIALISTS IN SPIRAL-WOUND GASKETS EXCLUSIVELY FOR OVER A THIRD OF A CENTURY

PREVENT:
PRIMING
FOAMING
CARRYOVER
and SCALE

. . and don't lose the B. T. U.s

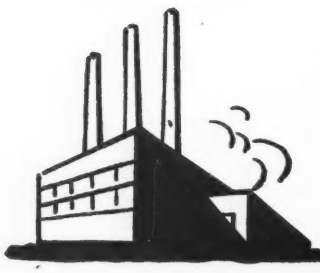
WITH

HENSZEY CONTINUOUS BLOWDOWN

The Henszey system keeps boiler water concentration within safe margins—preventing foaming, priming, carryover and the formation of sludge and scale (with proper chemical treatment). All this is accomplished, continuously, automatically and *WITHOUT* the HEAT LOSS of ordinary blowdown.

The savings due to clean, efficient boilers, in manpower, equipment and fuel are cost of production factors that are now doubly important.

The Henszey system of continuous blowdown is applicable to existing or planned boilers — send now for folder: "Complete Automatic Control of Boiler Concentration."



HENSZEY CO.
Department C1 Watertown, Wis.

HENSZEY

BOILER PLANT SPECIALTIES
• • •
CONTINUOUS BLOWDOWN

Boiler Feed Regulators • Distillation Systems • Heat Exchangers
Feed Water Meters • Flow Indicators • Proportioning Valves

Boilers At Kobuta

(Continued from Page 86)

the boilers, recording total solids in the continuous blowdown.

It is natural to expect that a centrifugal pump installed in the boiler-water circuit would be regarded as an outstanding weak point in the entire system. In actual practice, this has not proved to be the case at Kobuta. To date there has been no instance of circulation failure due to the pumps. The original installation required manual operation to place the idling pump in service should the loaded pump fail. This arrangement made it mandatory to station an operator at the pumps at all times. Physical layout has placed the pumps remote from the boiler-feed-pump bay, and in the future, boiler-installation designers might consider locating a forced-circulation boiler in such a manner that the circulation pumps can be attended by the normal boiler-feed-pump operator or water attendant.

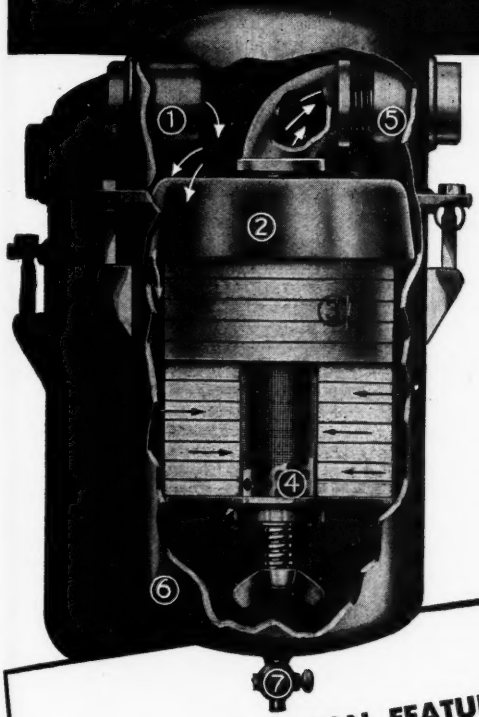
The stationing of the pump attendant was regarded as a stop-gap measure for emergency protection of the boiler, and at present quick-opening steam valves have been installed to bring the idling pump to full speed and rating automatically. The control for these valves is taken directly from a differential-pressure controller. When upsets resulted in low steam pressure to the pumps, and pump differential reached the low safe limit, the idling pump was automatically put in service in a very satisfactory manner. It is now believed that with this feature added and based on the performance of the pumps to date, the reliability of the circulation system is assured.

Comparative Performance

Efficiency and performance tests have indicated no outstanding differences in the two types of boiler units. The forced-circulation and the natural-circulation units have been and are consistently operated at 85 per cent efficiency. Steam requirements for normal operation of the pumps of the forced-circulation unit amount to 10,000 lb per hr, or 3 per cent of the boiler capacity.

It has been observed that the natural-circulation units form considerable sludge in the vicinity of the downcomer tubes at the top drum. In the forced-circulation unit, this sludge with additional scale particles collects on the orifice strainers tending to plug the control orifices. On two occasions this plugging of orifice strainers has resulted in tube starvation and failure. It has been particularly observed that at no time have scale particles been encountered on the natural-circulation units receiving the same feedwater and treatment. The exact location of the origin of these scale particles has not yet been determined, but they appear to form in the region of the distributing headers ahead of the orifice strainers. Chemical compo-

HAZARD of Oil and Moisture in Automatic Controls NOW ELIMINATED



New Filter Delivers Dry Air Only

Amazing results are being reported by users of the Model AAPHS Pipe Line Filter as a final stage in the protection of delicate pneumatic control instruments.

Typical comment is that of a large producer of electric and steam power who says, "We tried several well-known methods of moisture and oil elimination without satisfactory results. Your Model AAPHS was finally installed in the air line and since then we have had no trouble whatever with oil or moisture in our automatic controls."

NEW 44-PAGE CATALOG: Describes entire line, including filters for building ventilation, pipe lines, engine, and compressor intakes. Your copy is ready.

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31 CENTRE PARK, ROCHESTER 3, N. Y.
"Air Filter Headquarters"

STAYNEW PROTECTOMOTOR FILTERS

CONSTRUCTION FEATURES

(1) inlet; (2) baffle that distributes vapor-laden air to sides of container (6); (3) felt rings; (4) perforated liner; (5) outlet; (7) drain cock; (8) swing bolts for easy inspection (optional).

THICK FELT RINGS that remove every trace of oil or moisture.

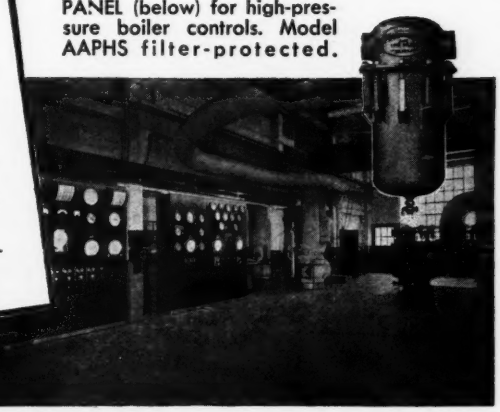
SPECIFICATIONS

Model	Standard Pipe Size	Capacity	Model	Standard Pipe Size	Capacity
AAPH-02 AAPHS-02	¼"	5 CFM	AAPH-2 AAPHS 2	1"	33 CFM
AAPH-01 AAPHS-01	¼"	7 CFM	AAPH-4 AAPHS-4	1½"	50 CFM
AAPH-0 AAPHS-0	½"	10 CFM	AAPH-5 AAPHS-5	2"	100 CFM
AAPH-1 AAPHS-1	¾"	20 CFM			

Letter S in code numbers indicates swingbolt type which facilitates inspection.

Write for Bulletin

PANEL (below) for high-pressure boiler controls. Model AAPHS filter-protected.



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CORAVOL in your steam system (1) prevents corrosion in steam and condensate lines, (2) cleans out clogging rust deposits resulting from previous corrosion. Thus, **CORAVOL** *protects lines;* increases effectiveness of heat transfer surfaces; restores original capacity of lines and the operating efficiency of valves and traps.

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sition of these scale particles is identical with that of the soft sludge which is formed in the natural-circulation boilers.

Removal of the sludge is accomplished in the natural-circulation boiler by the conventional tube turbining of the downcomers with final removal at the mud drum.

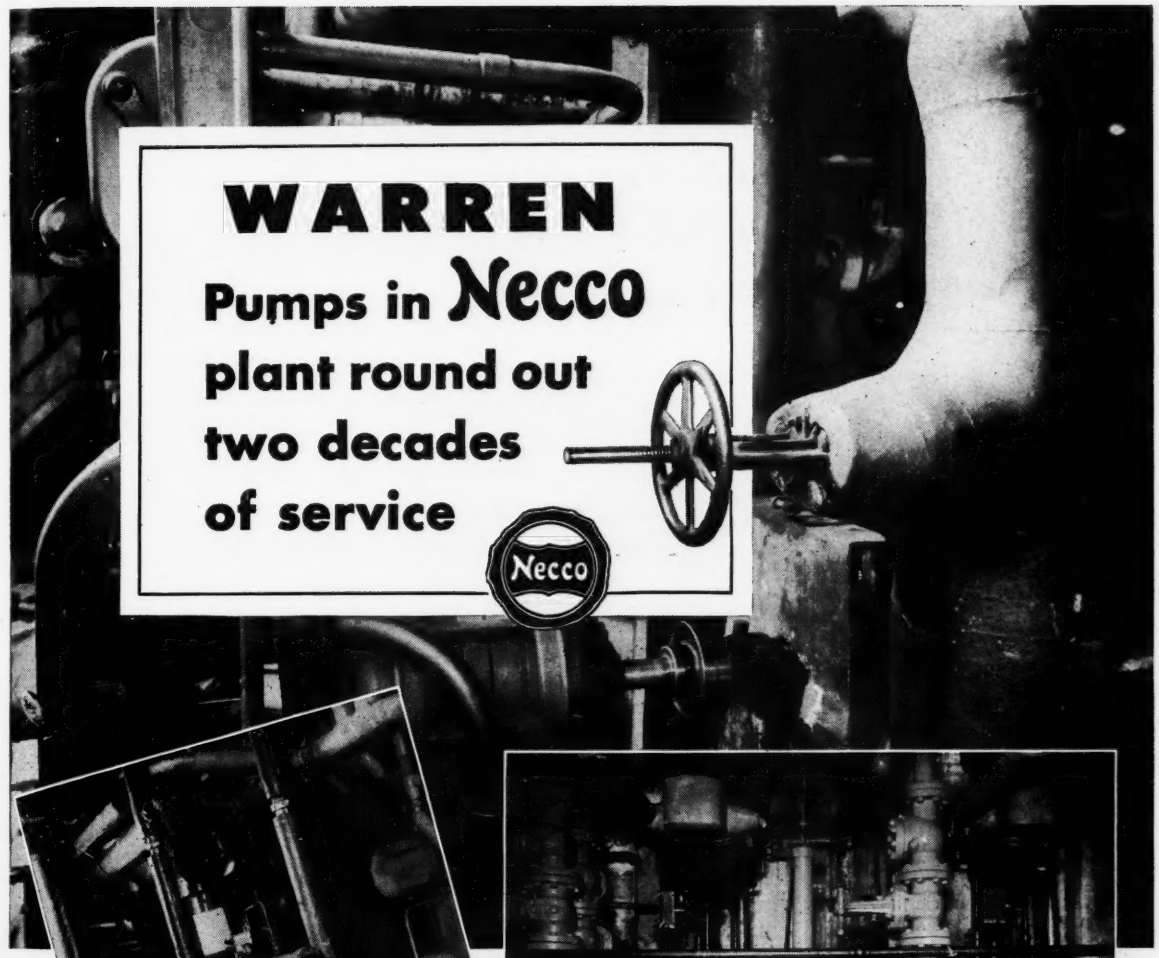
In an effort to improve the availability of the forced-circulation unit, and to minimize the work required for sludge and scale-particle removal, two external strainer drums have been installed in each of the pump-discharge lines as near as possible to the orifice headers. Results observed on two occasions, since installation, reveal conditions in general to be no better than prior to their installation. No definite conclusion concerning scale formation at this location has been advanced.

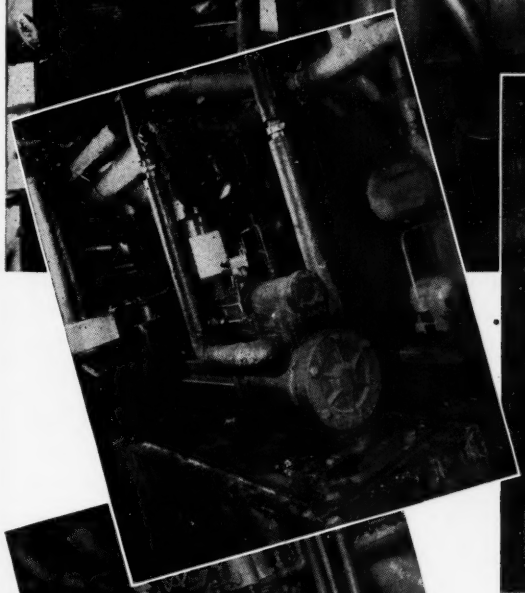
The apparent failure to remove the scale particles by mechnical means in the forced-circulation unit and the desirability of preventing sludge accumulation in both types of boilers has led all concerned to an attitude that the problem is one of chemical treatment and elimination of the formation of the sludge and scale rather than removal of scale particles after they have formed. A modified chemical treatment is now being used to overcome this condition and so far the results appear favorable.

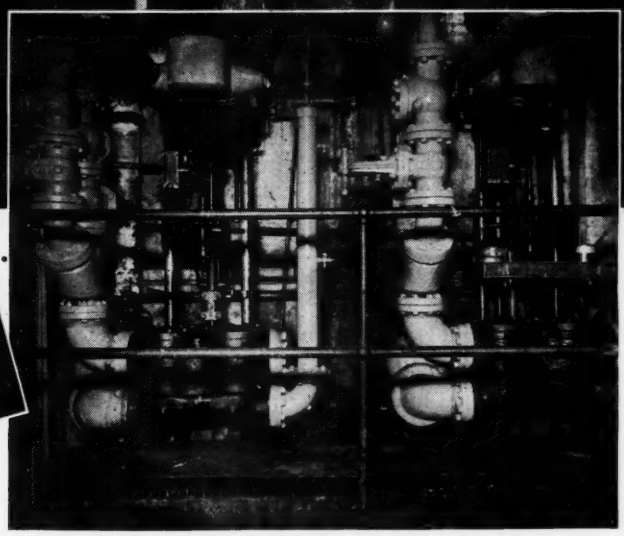
The forced-circulation type of boiler has proved to be much more stable than the natural-circulation boilers from the standpoint of water level with varying operating conditions. The pumping rate is 5100 gpm, or 1,900,000 lb per hr which gives a ratio of circulated water to steam of 5½ to 1 at rated load.

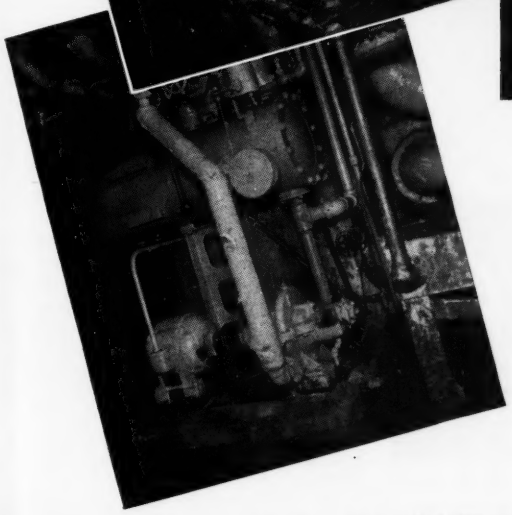
In a natural-circulation boiler the rate of water circulation increases with rating, probably resulting in considerable turbulence in the steam drum at higher load conditions. With a slight lowering in drum pressure due to suddenly increased steam demand, "swell" tends to upset feedwater regulation. This condition can only occur in the natural-circulation type of boiler unit. Consequently, the forced-circulation boiler-water level will be upset to a lesser degree by rapid and large load changes regardless of feedwater control than with the natural-circulation boiler. However, the natural-circulation units have, on a number of occasions, experienced load changes from 200,000 to 400,000 lb per hr without seriously upsetting water level and with no sign of carry-over. The ability of the operators and of the feedwater control to handle these conditions indicates that natural-circulation units can take rapid load swings without serious water-level upsets.

The expectation that the forced-circulation boiler with its closely spaced 1¼-in. tubes would present a nearly solid water-cooled metal sur-









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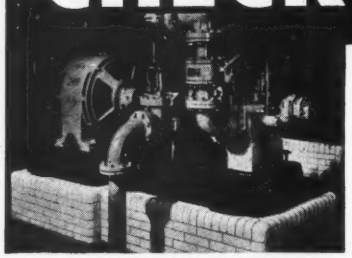

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Williams-Hager Flanged Silent Check Valves completely eliminate "Hammer" and "Bang" in the lines, provide uninterrupted constant flow of liquids.

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face to the furnace and that slag would not so readily adhere to this surface, has not been realized. Wall soot blowers were installed slightly above burner level to aid in removing this slag deposit. With coals of the quality now burned, with an ash-fusion temperature between 2300 F and 2400 F, wall blowers or lancing will not be required for the natural-circulation units.

Tube ruptures at different times on both types of units afforded the opportunity for boiler operators to compare urgency of removing the boiler from service. With chemical operating units unable to reduce steam demand safely at a moment's notice, the forced-circulation boiler, in one case, was kept on the line at full rating in excess of 3 hr, despite a complete wall-tube rupture. This type of boiler, with its relatively smaller diameter tubes and small control orifice in the water inlet, in addition to the fact that the generating tubes terminate above the water level in he drum, can suffer a complete tube rupture without the necessity of immediate removal from the line. This is an extremely vital factor in chemical processes where shutdowns must be made in an orderly and safe manner. In the two instances when rupture occurred in a wall tube or generating tube on the natural-circulation units, it was necessary to take the boiler off the line immediately, resulting in pressure upsets to chemical process. A natural-circulation boiler, upon loss of any tube, immediately becomes inoperable.

Conclusion

The forced-circulation unit has demonstrated particular operating assets as follows:

1. The ability to suffer loss of a tube and continue to operate until other apparatus is brought on the line to take its place, or until load can be sufficiently reduced so that boiler capacity is not required.

2. Water-level stability under conditions of rapid and large load changes.

The natural-circulation units have particular operating assets as follows:

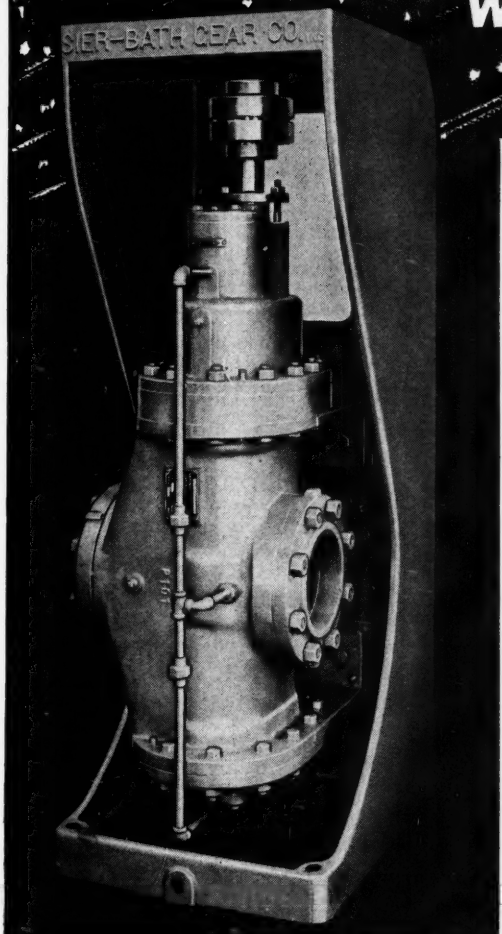
1. Greater availability in comparison with forced-circulation type.

2. Less sensitivity to changes in feedwater conditions, rendering it more suitable for high make-up with high solids in the feedwater.

3. Lower susceptibility to scale formation under equivalent feedwater conditions.

The operating record of both of these types of steam generators reveals their ability to supply process-steam requirements under many adverse conditions. Chemical production of Butadiene and Styrene has been maintained at high rates throughout the operating period to date, and over-all operation should compare favorably with that of any other steam plant of its size and operating conditions.

Winter Pumping is Easier with SIER-BATH SCREW PUMPS



SIER-BATH SCREW PUMP Vertical Model
Available also in horizontal model. This unit handles Bunker C Fuel Oil. Rated at 350 g.p.m. 50 p.s.i., 10" vacuum 20 h.p. 1150 r.p.m. motor drive. Built for Y tankers A.S.F.

These pumps eliminate the need of maintaining low fluid viscosities in cold weather. Hence, they reduce heating steam consumption and minimize fluid carbonizing. Sier-Bath Screw Pumps handle highly viscous fluids without pulsation because they apply the tremendous thrust of quadruple screws.

In fuel oil burner service, the Sier-Bath Screw Pump's pulseless discharge produces an even, steady flame that reduces tip carbonizing and promotes boiler efficiency. It does not strain piping as does a battering intermittent delivery. Quiet in operation, Sier-Bath Screw Pumps are higher in efficiency and less affected by head. They need neither heavy foundations nor deep bolting. They have anti-friction roller bearings as standard design and removable liners may be specified. Write for bulletin.

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Sier-Bath Gear Co. Inc.

Only Two Moving Parts

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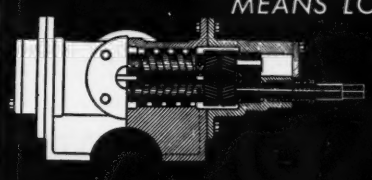
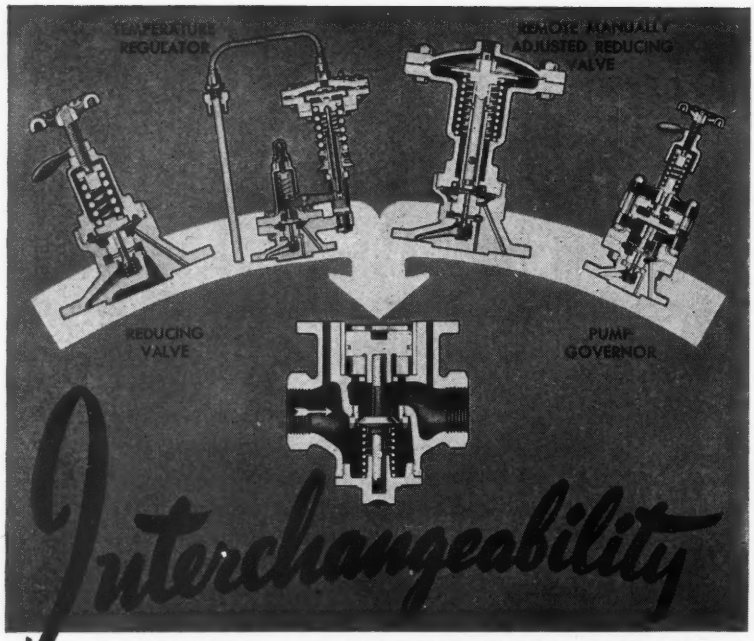


Only an occasional packing is needed and that can be done while pump is running.



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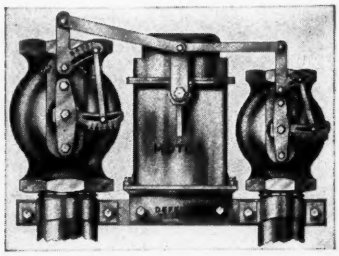
Cold Setting Plastic

THE IRVINGTON VARNISH & INSULATOR CO., Irvington 11, N. J., has introduced a cold setting plastic to be used as a filling material for junction boxes, stuffing boxes, pot-heads and similar spaces encountered in electrical work.

This liquid resin, known as Cardolite 5616, is mixed with Irvington 5612 Setting Agent prior to use. Approximately 4 hr after mixing, the 2 ingredients will gel at room temperature to the point where flow is no longer possible, and after several days, the end product is a tough rubbery mass which will not flow under heat nor become brittle in the cold. The set compound is insoluble in water, oil, acids and alkalies. Although Cardolite 5616 will adhere to metal, it can be stripped away cleanly to allow repairs to terminals and cable strips.

Proportioning Valves

DEFENDER INSTRUMENT & REGULATOR CO., St. Louis, Mo., has announced an improved design of self-regrinding chronometer valve equipped with adjustable proportioning levers. These valves are linked together and operated by a reversible motor so as to control the flow of steam, oil, hot water, liquids or chemicals of various kinds.



These valves can be made of metal suitable for the handling of any liquid or gas and the provision of proportioning levers bring them into the field of throttling control. The operating lever can at all times be moved its full stroke, while by very simple adjustments on the slotted levers, the ports in the valve will operate from full open to full closed, or from full open to any per cent closed, or from full closed to any per cent open, or any per cent movement, between open and closed. Hence either valve can be adjusted independently of the other without affecting the adjustment of the other valve.

Electrode for High Tensile Steels

A NEW SHIELDED arc electrode, designated as "Fleetweld 11-HT," for groove butt joints and welding horizontal or flat fillets in the higher

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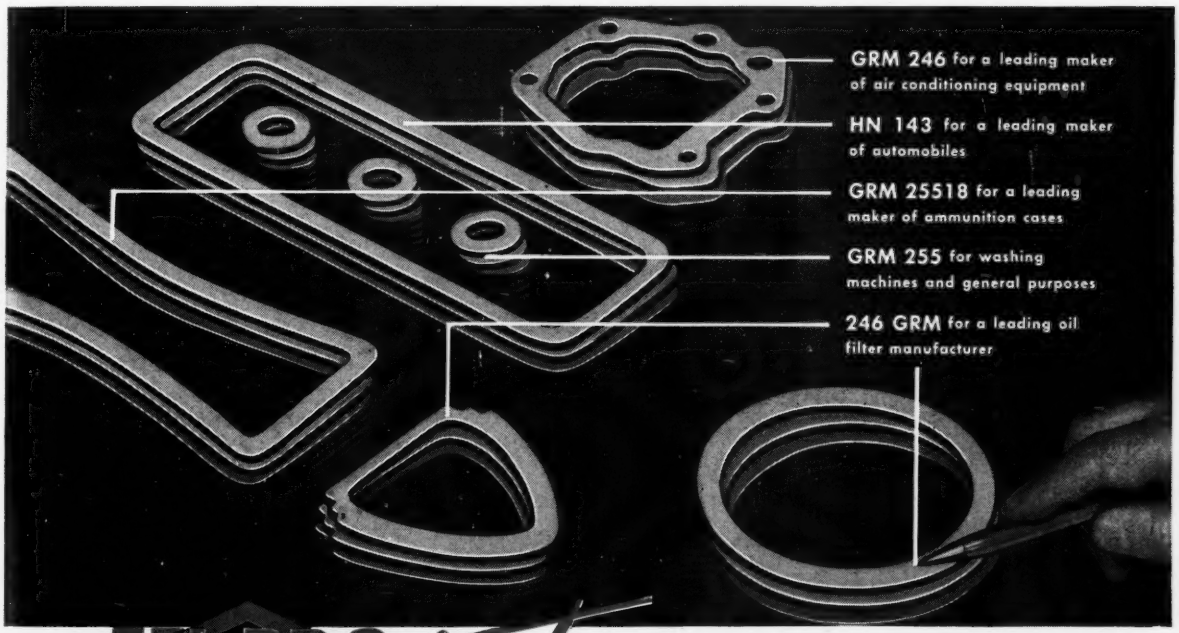
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DART UNIONS

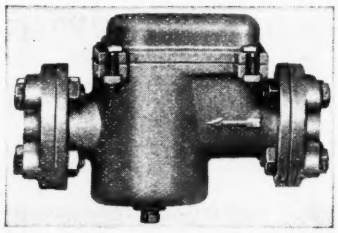
tensile steels, such as A. S. T. M. A-212, has just been announced by The Lincoln Electric Co., Cleveland, Ohio.

Exhaustive field tests have shown that the quality of groove butt joints made with this new electrode are exceptionally good and free of porosity, and fillet welds are extremely smooth with a flat face. The electrode has a low spatter loss and welds are produced with a steady arc and are free from undercut. The electrode may be used with either alternating or direct current.

Low-Swing Strainer

SEVERAL IMPROVEMENTS over existing equipment are claimed for a new Blackmer strainer recently announced by Blackmer Pump Co., Grand Rapids, Michigan.

Advantages claimed for the new strainer are: Use of perforated metal, steel or bronze, instead of wire screen for the strainer basket makes the basket less liable to damage in cleaning and gives it longer life. Slotted lugs of the top plate line up with the lugs of the strainer body to receive



the four holding bolts. This permits quicker removal of basket for cleaning. Compact design permits mounting in small space or in lines along walls. Strainer is designed for flange mounting. Companion flanges are included as a part of the unit.

Present production is limited to a capacity of 100 gpm with 2-in., 2-1/2-in., and 3-in., intake and discharge sizes. Maximum operating temperature is 600 F. Maximum pressure is 75 psi. Larger and smaller sizes will eventually be added to the line.

Corrosion-Resistant Coatings

COATING OR PAINT, in which the particle size of the solid content is reduced to 0.001 micron is the claim made by Protective Coatings Inc., Detroit 27, Mich., for their Alkacite series for industrial service.

When applied to any porous surface —metals, wood, concrete and similar or allied products it is a characteristic of Alkacite to penetrate the surface, effectively blocking off moisture penetration, acid reaction, retarding corrosion, rotting and disintegration of the structural material. It is claimed that a film of Alkacite only 0.001 micron thick, applied to metals, will resist hydrostatic pressures exceeding 100 psi for months.

The Alkacite series of protective coatings now planned includes 12 or more formulations to meet a wide range of industrial needs. Among those now ready are:

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SKINNER "UNIVERSAL UNAFLOW" STEAM ENGINE
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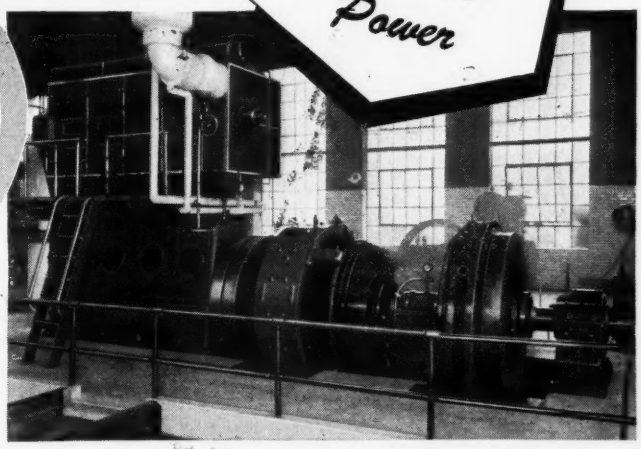

The 4-cylinder "Universal Unaflow" Steam Engine driving 600-kw. D-C Generator, and 500-kv.a. A-C Generator, in The R. K. Le Blond Machine Tool Company power plant.

THE R. K. Le Blond Machine Tool Company in Cincinnati is a glorious monument to its able founder, who, after serving at its head for 58 years, still occupies the position of Chairman of the Board. It is also a fine tribute to his character that many of his early associates are still with him. Mr. Le Blond has guided the destinies of his company, from the days when he worked with two assistants in one small room, to the present time when its renowned machine tools go from the huge present plant to all parts of the earth.

It is a matter of pride with us to have installed a "Universal Unaflow" Engine-Generator Unit in any plant with as fine a record as that of the Le Blond Company. It is doubly so when the engine has been selected by so competent and efficient a group of experts. No better qualified staff of engineers can be found today than those who work with The R. K. Le Blond Machine Tool Company, and it is a coincidence that in the early days Mr. Le Blond himself actually built steam engines.

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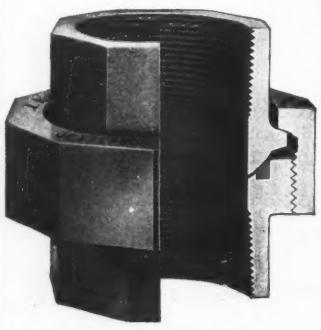

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It is cut from seamless drawn tubing—free from all casting defects—sound and uniform always! It cannot be dislodged by a pipe end screwed in too far.

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ft) base, prime or finish coat, glossy black, that forms a dense, smooth film for protection of structural steel in stock, reserve and in transit; also used for protection of fume ducts, and many other uses.

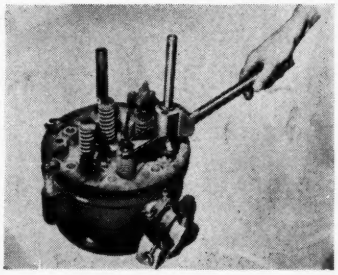
2. Alkacite No. 102: A heavier formulation for brushing. This is a general-use formulation, since one coat normally is sufficient for satisfactory service. Glossy black. Coverage 600-800 sq ft to the gallon.

3. Alkacite brushing mastic: applicable to tank linings for water, acid and alkali solutions, as in plating, processing, pickling, storage, etc. as alternate to more expensive materials. One gallon covers to 150 sq ft on metal. Also for wood and concrete structures.

4. Alkacite No. 103: Aluminum. Coverage to 1200 sq ft to gallon by spraying.

Valve Spring Depressor

A NEW VALVE spring depressor designed for one man operation in dismantling and assembling Diesel engine vales is now manufactured by the Paxton Diesel Engineering Co. of Omaha, Neb. It is called the Safe-N-Ezy Valve Spring Depressor. The new tool will compress a valve spring



to any point and hold it there. This leaves the mechanic's hands free to remove the keepers and pin and then proceed with the job. It does not nick the stud and is so designed that the spring can be released safely and simply.

These depressors are available in sizes and models to fit all modern Diesel engines. The tool is ruggedly constructed, light-weight, and easy to store.

Ballasts for Fluorescent Lighting

AMERICAN TRANSFORMER CO., Newark, N. J., has just introduced a line of ballasts for hot and cold cathode fluorescent lighting. Long experience in manufacturing precision transformers makes this a logical development for this company. The manufacturer claims for AmerTran ballasts an exceptionally close matching with tube characteristics thus assuring maximum lamp life and maintained brightness. It is also claimed that flicker, end-blacking, premature burnouts are reduced. Extremely quiet in operation, the new AmerTran ballasts are suitable for installation where the noise level is low as in churches, homes, lecture halls, and offices.

IMPROPERLY TREATED BOILER WATER

RESPONDS TO Dearborn ENGINEERING SKILL

Dearborn Engineer does this for you . . .

1. *Studies* your water and plant operating conditions.
2. *Sends* samples of your water to main laboratory for analysis.
3. *Recommends* the proper chemical treatment and correct chemical control methods.
4. *Supervises* installation of feeding equipment.
5. *Instructs* your men on water test methods for treatment dosage adjustment and blow-down control.
6. *Calls* regularly at your plant to insure maintenance of the recommended conditions.

An accurate analysis and survey of your plant by the Dearborn Engineer is the first step in solving any water treating problem.

Initial corrective measures are suggested and after consultation and additional analyses by the main Dearborn Laboratory, final and complete recommendations are made.

In using the Dearborn method of treatment and control, periodic check-ups and supervisory service keep steam production up to the required capacity.

Contact the Dearborn Engineer in your vicinity, when you have boiler water problems. Dearborn engineering skill makes any water fit required operating conditions.

Dearborn

TRADE MARK REGISTERED

THE *LEADER* FOR OVER HALF A CENTURY

ENGINEERING SERVICE AND WATER TREATMENT

DEARBORN CHEMICAL COMPANY

Dept. F, 310 S. Michigan Ave., Chicago 4, Illinois

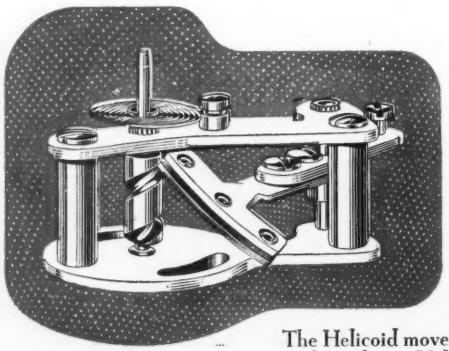
The proof of the pudding is in the eating. And the proof that Helicoid Gages* will last longer is determined only by your own experience.

During the last four years, many endurance tests have been made on pressure gages by large gage users. Every such test has proven that Helicoid Gages greatly reduce maintenance expense.

However, your own test is the most conclusive for you. If you haven't yet found out what Helicoid Gages can do to save money, try them yourself. . . . Specify them in the future.

*Formerly called "Certified."

See your nearest Distributor.



The Helicoid movement is used exclusively in Helicoid Gages

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
BRIDGEPORT 2, CONNECTICUT

TRADE MARK

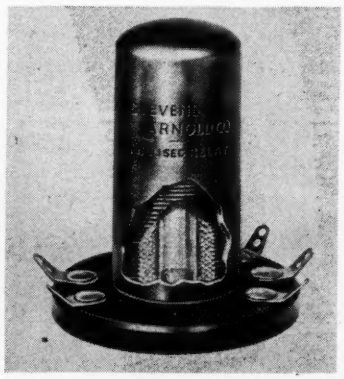
In Business for Your Safety

1-CG-2

The AmerTran ballast may be recognized by its distinctive roll-turn lead-out that prevents strain on lead insulation and makes wiring easier. Since this lead-out is of the two-way type, it may be readily attached to exterior or interior channels.

High Speed Relay

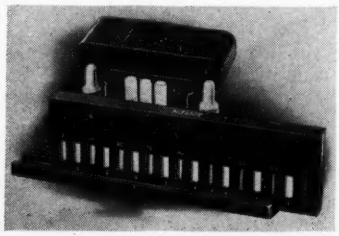
A HERMETICALLY sealed sensitive relay capable of speeds up to 1000 operations per second, has been developed by Stevens-Arnold Co. Inc., 22 Elkins St., South Boston, Mass., and is being marketed under the trade name of a Millisec Relay. The basic design of the moving elements is distinctive and makes the ultra high speed possible, at the same time assuring great reliability if operated in the usual speed ranges.



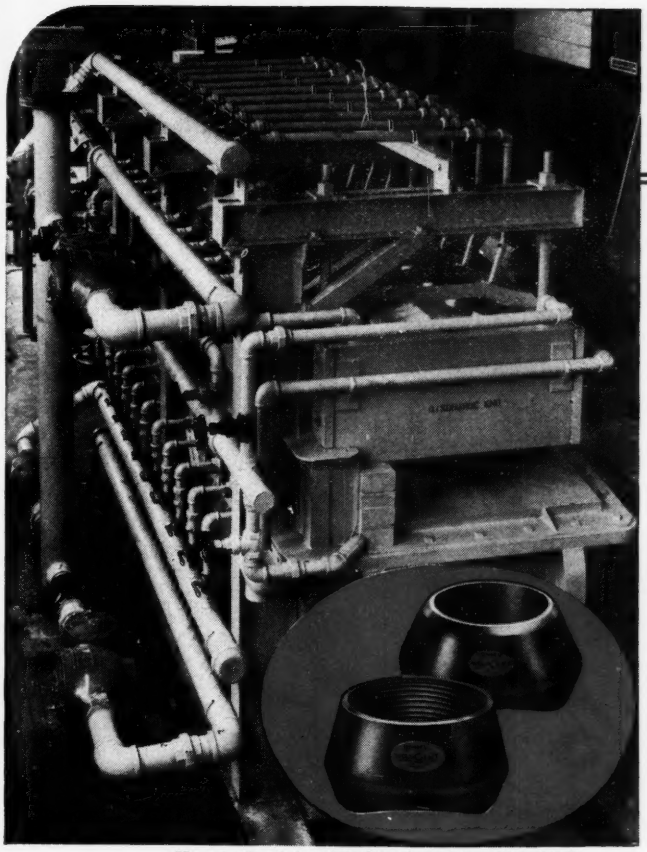
In the illustration a cut through section shows the glass envelope which surrounds all the moving parts and protects them from moisture, dust or corrosive fumes. With this new type of construction, sensitivities down to 1/2 milli watt are possible. Ratings up to 5 amp can be obtained. Closing time can be less than one milli second. The outside dimensions of the 115-v ac 1-amp rating are 3-in. high and 1/2-in. base diameter.

Nitrate Comparator

A SIMPLE ACCURATE test for the nitrate in boiler water has been developed jointly by W. H. & L. D. Betz, Philadelphia 24, Pa., and W. A. Taylor & Co., Baltimore 4, Md. The Taylor-Betz Nitrate Comparator finds particular application in routine plant



control of the Nitrate/Hydroxide ratio in boiler waters for the prevention of embrittlement. The equipment consists of a comparator base and slide covering the range 0 to 100 ppm nitrate in nine gradations. An initial supply of reagents is furnished with the comparator. The accuracy of the method is not affected by ions normally present in boiler water.



By Permission of the Selas Corporation of America

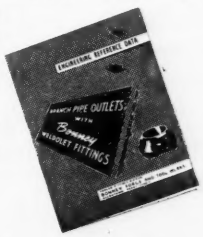
How to Reduce Pressure Loss

IN PIPING SYSTEMS

HOW to reduce pressure loss at right-angle branch pipe outlets has always been a problem to piping engineers. The reason for this pressure-drop is the abrupt change in the direction of flow which creates excessive turbulence at the joint. This turbulence tends to cause "dead-spots" which restrict flow into the branch line.

WeldOlet Fittings overcome this problem because they are designed with a funnel-shaped inlet. This funnel-shaped inlet reduces turbulence and provides greater flow area into the branch line. Pressure-loss is reduced and flow-efficiency is increased.

The accompanying illustration of a continuous gas furnace shows how the SELAS CORPORATION OF AMERICA uses WeldOlet Fittings on gas manifolds feeding burner lines. The use of these fittings reduced pressure loss and provided the desired burner efficiency.



Get full information on these more efficient, easier to install fittings today. Write for a copy of the new WeldOlet Fittings Catalog.

Forged Fittings Division

BONNEY FORGE & TOOL WORKS · 639 N. Meadow St., Allentown, Pa.

BUY MORE BONDS AND KEEP THEM

WELDOLETS
TRADE MARK REG. U. S. PAT. OFF.
PAT. IN U. S. & FOREIGN COUNTRIES
WELDING OUTLET - THREADED OUTLET - SOCKET OUTLET
For Welded Branch Pipe Outlets

FULLER ROTARY COMPRESSORS
BUILT FOR CAPACITIES TO 1800 C F M PRESSURES TO 125 LB VACUUMS TO 20 90 IN REFERRED TO 30 IN BAROMETER AND VACUUM PUMPS
"SPOT" YOUR COMPRESSORS
FULLER
FULLER COMPANY

Why— long distance pipe lines and their attendant losses and upkeep?

Locate your compressors in the departments where air is required. Eliminate the cost of long distance pipe lines, consequent leaks, upkeep, and accompanying line friction losses.

With compressors "*spotted where you need the air*", they can be shut down when the various departments have completed their daily cycle of operations. This means a saving in power, supervision, and maintenance . . . in many cases has paid for the installation in a comparatively short time.

Bulletin C-5 illustrates and describes these machines. It's yours for the asking.

FULLER COMPANY
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Chicago 3 · 1144 Marquette Bldg.
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No. 3 of a series

C-111

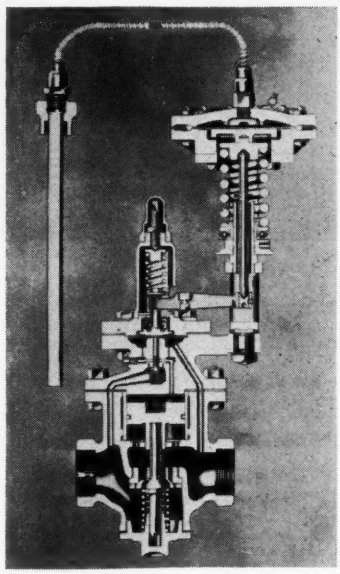
FULLER
PIONEERS OF HIGH-EFFICIENCY ROTARY COMPRESSORS

Temperature Regulator With Duo-Matic Control

A SELF-CONTAINED, spring loaded, internal pilot, piston operated temperature regulator for steam service, has been announced by Leslie Co., 257 Grant Avenue, Lyndhurst, N. J. Duo-Matic control is a prominent feature of the new regulator, whereby both accurate temperature regulation and pressure control are obtained simultaneously with a single regulator.

The new regulator has a wide range, rugged thermostatic element with 100 F, adjustable temperature range. It is single-seated for positive dead-end control. It is equipped with metal diaphragms, has no bellows or packing glands, thus leaks are eliminated and minimum attention is required.

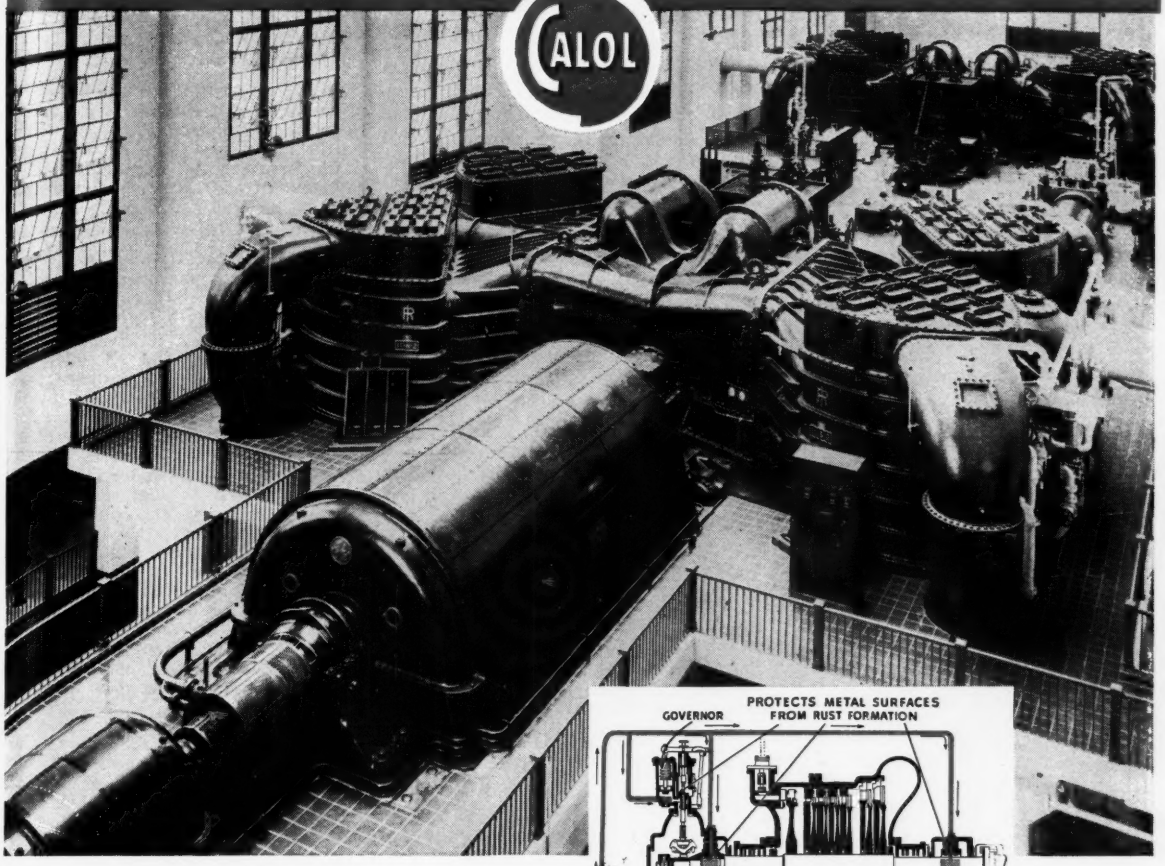
All wearing parts are renewable which allows complete overhaul without removal from the pipe line. Corrosion and wear resistance is obtained with the use of stainless steel hardened wearing parts. Vital parts are hardened to at least 500 Brinnell.

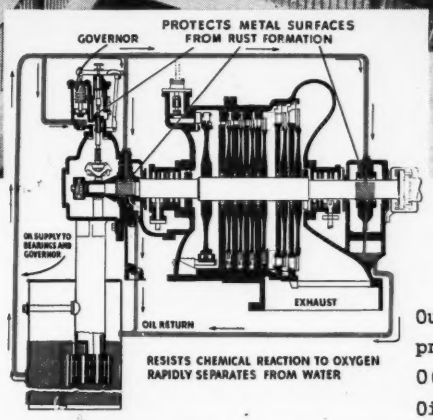


A vapor filled thermostatic element acting through the upper diaphragm and lever opposes pressure limit spring and determines the steam pressure delivered by regulator to heat exchanger. Manual compression of the limit spring determines maximum outlet pressure and opens controlling valve admitting high pressure steam from inlet body port to top of piston which opens main valve. The outlet steam pressure acting under steam diaphragm balances compression of limit spring, throttling controlling valve and limiting the maximum outlet pressure.

Temperature at which the vapor pressure starts to oppose the limit spring and decrease outlet steam pressure is set on the adjusting spring. This spring opposes the vapor pressure through the large upper diaphragm and by means of this spring the temperature at which all steam to heater will be shut off can be accurately set. Temperature drop of 1 F at bulb reduces vapor pressure,

Major power company picks Calol Turbine Oils





Southern California Edison Company, one of the largest producers and distributors of electric power in the country, has been using Calol Turbine Oils in steam turbines installed in the No. 3 Plant of its Long Beach Steam Station, for the past sixteen years.

The rapid expansion of industry has resulted in the installation of larger and improved turbines by such concerns as Southern California Edison. Keeping pace with these developments, Standard of California has constantly improved its lubricants to meet the requirements of modern equipment.

Our new improved Calol OC Turbine Oils are outstanding examples of this progressiveness. These unusual oils contain an oxidation inhibitor and a corrosion inhibitor. They eliminate rusting and provide economical, gum and sludge-trouble-free lubrication in the toughest kind of service.

There is a proper grade of Calol OC Turbine Oil for every condition of turbine lubrication. This oil, in every grade, meets the exacting specifications of the leading turbine manufacturers.

For additional information and the name of your nearest Distributor, write Standard of California, 225 Bush Street, San Francisco 20, Calif., or California Commercial Company, 30 Rockefeller Plaza, New York 20, N. Y.

FOR EVERY JOB A STANDARD OF CALIFORNIA TEST-PROVED PRODUCT

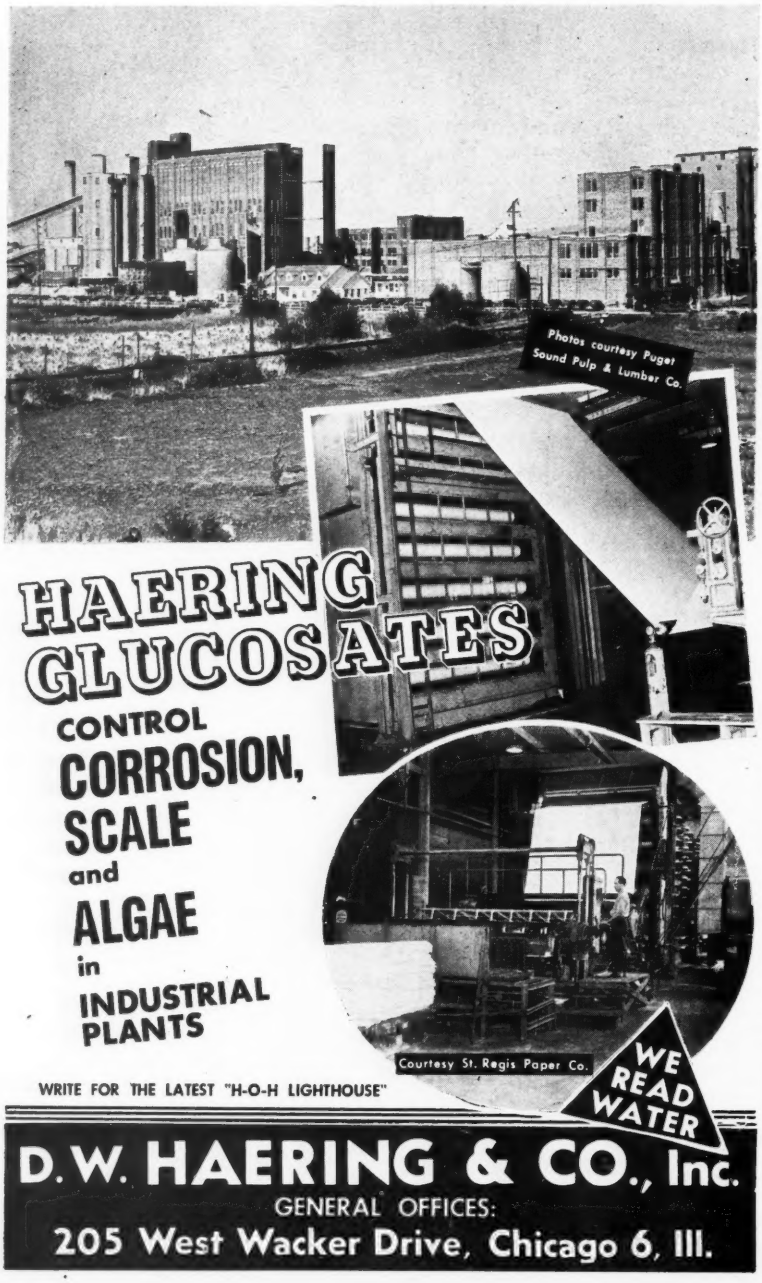
allowing limit spring to open controlling valve and deliver an increased steam pressure to heat exchanger. Outlet steam pressure is, therefore, always directly proportional to the change in temperature at bulb and this pressure is automatically maintained regardless of the volume of steam used by heater or variations in supply pressure.

Flux Removal

OPTIMUS DEOXIDANT No. 3 has been developed by Optimus Detergents Co., 241 Church St., Matawan, N. J., for removing flux, and welding and brazing scale. It is being used to deoxidize the surfaces of a wide variety of metals and alloys.

This compound being acidic in nature, may be used in most metals as a mild deoxidant without serious etching of the surface. It is used regularly on welded steel tubing, brazed, hot rolled and cold rolled steel, copper, brass, welded aluminum, cast iron, bronze castings and most aluminum alloys.

In general, oxides are removed with the formation of very little or no smut. With the use of Optimus Deoxidant No. 3 most welding and brazing scales are removed in from 5 to 15 min. Longer times tend to produce a smut with some alloys.



Obituaries

Alan E. Flowers

DR. ALAN ESTES FLOWERS, 69 years of age, died on December 3 in Vassar Hospital, Poughkeepsie, N. Y. For more than twenty years he was head of the Research and Development Department of the De Laval Separator Co.

Dr. Flowers received his Bachelor's Degree from Cornell University in 1902 and obtained his Master's Degree in engineering in 1914 and his Ph.D in 1915, both at Cornell. Dr. Flowers was asociated with the Engineering Department of Westinghouse Electric Corp. from 1902 to 1904; Instructor and Associate Professor of Electrical Engineering at the University of Missouri frob 1904 to 1912; the General Electric Co. from 1912 to 1913; Professor of Electrical Engineering, Ohio State University, 1917 to 1918; appraisal engineer for the Columbus Railway, Power and Light Co. from 1917 to 1918; Captain of the Signal Corps of the U.S.A. Development Section from 1918 to 1919; Test Engineer, Engineering Department, National Aniline & Chemical Co., New York, 1919-1920; research engineer in charge of research engineering section, 1921 and 1922; manager and consulting engineer, Chemical Machinery Construction Co., 1922-23; engineer in charge of development, De Laval Separator Co., 1923 up to the time of his death.

Dr. Flowers was the author of many engineering articles, but best known of his writings is the chapter on Centrifuges in the Chemical Engineers Handbook. In his career with De Laval, Dr. Flowers made many contributions to science.

NEWS *from* THE FIELD

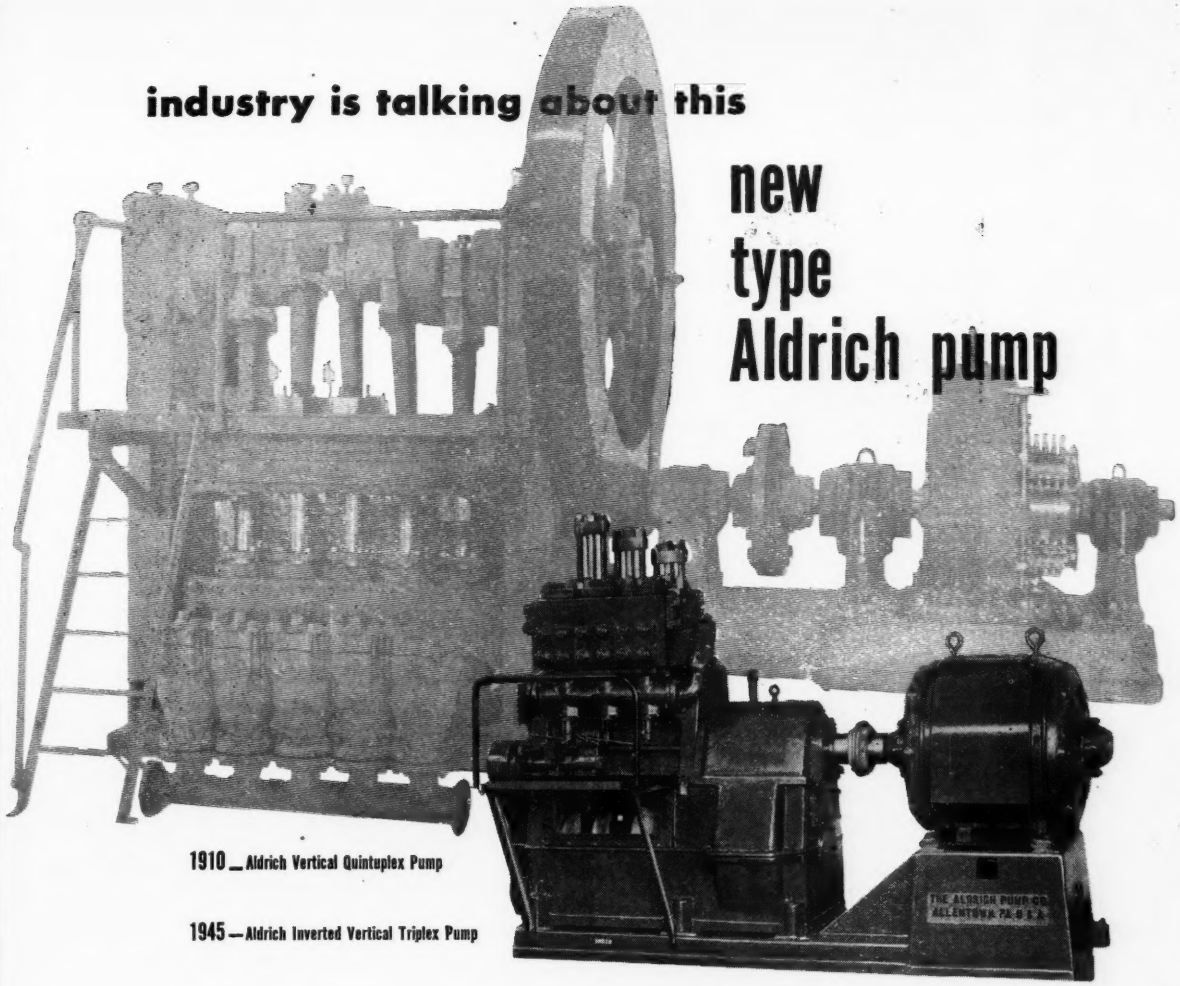
Percy Nicholls Award to T. A. Marsh

THOMAS A. MARSH, widely known authority on combustion engineering and national industrial engineer for the Iron Fireman Mfg. Co., of Cleveland, was awarded the 1945 Percy Nicholls award for notable scientific and industrial achievement in the field of solid fuels, at the annual meeting of the American Society of Mechanical Engineers. Mr. Marsh is the fourth man to whom this annual award, the only one in the field of solid fuels, has been made. It was presented jointly by the Fuel Division of the ASME and the Coal Division of the American Institute of Mining and Metallurgical Engineers.

Mr. Marsh was graduated from the University of Illinois in 1904 and was conferred the degree of Mechanical Engineer in 1909. His entire profes-

industry is talking about this

new type Aldrich pump



1910—Aldrich Vertical Quintuplex Pump

1945—Aldrich Inverted Vertical Triplex Pump

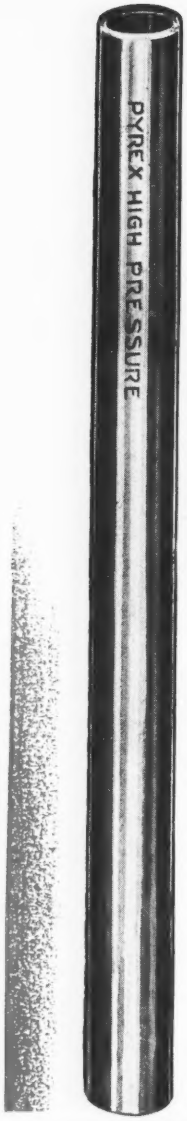
• Recently installed in a steel mill, an Aldrich Inverted Vertical Triplex was placed alongside a 35 year old Aldrich Quintuplex Pump of similar capacity which, by the way, is still giving satisfactory service.

This modern Aldrich pump, designed to deliver 200 gpm against 1000 psi, weighs 65% less than its elderly but able companion, requires only 24% of the floor space, and the height is reduced from 12 feet 5 inches to 7 feet 4 inches. In addition to reducing initial cost, saving space and maintenance, modern Aldrich pumps are built for even longer life at less operating expense. No wonder they are talking about Aldrich Pumps. That's progress!

How can you benefit by Aldrich modern pump developments? Call on Aldrich engineers for assistance with your pumping problems. They have had more than forty years' experience in this work and their specialized knowledge is available to you. Write to The Aldrich Pump Co., Allentown, Pa.

Representatives: Akron • Birmingham • Bolivar, N. Y. • Boston • Chicago • Cincinnati • Cleveland Denver • Detroit • Duluth • Houston • Jacksonville • Los Angeles • New York • Omaha Pittsburgh • Portland, Ore. • St. Louis • San Francisco • Seattle • Tulsa

ALDRICH . . . anticipates industry's pumping needs



Gauge Glasses

TESTED

for Temperature Shock

Heated to a temperature of 425°F and then plunged into ice water creates several times the thermal shock that any gauge glass is called upon to withstand. Yet that is a routine test for Pyrex Gauge Glasses. That is only one of the reasons why they stand up under actual service conditions.

Machine drawn accuracy that permits easy installation and reduces to a minimum installation strains that cause breakage, remarkable resistance to the solvent action of hot water or steam, a hard smooth surface that resists abrasion and scratching—are other factors which make Pyrex Gauge Glasses the most economical glass you ever used. Corning Glass Works, Corning, N. Y.

"PYREX" and "CORNING" are registered trade-marks and indicate manufacture of Corning Glass Works, Corning, N. Y.

CORNING Glass Works Corning, New York

Pyrex Gauge Glasses BRAND

"Boiler Repairs Reduced 75%"

writes user of **NATIONAL GIRTH SEAM PROTECTOR**

We have been using the National Girth Seam Protector for several years and they certainly do the job. . . . Have reduced our boiler repairs at least 75% since using these protectors, one of the best investments we ever made.

Von Platen-Fox Co.
Iron Mountain, Mich.

You, too, will find the National Girth Seam Protector saves trouble and money by preventing leaks and fire-cracking on new or old seams in boilers. Sections consist of wedge nut, cap screw metal lug and refractory covering; are easily attached. We can make immediate deliveries. Send for descriptive bulletin.

NATIONAL BOILER PROTECTOR CO., 740 REIBOLD BLDG., DAYTON, OHIO

sional life has been directed to the better utilization of coal and the design as well as application of equipment to accomplish this result.

Since 1934, Mr. Marsh has directed his efforts to the field of industrial stokers through his position with the Iron Fireman Mfg. Co. Mr. Marsh did pioneering work in the successful burning of lower rank coals largely through the design and development work in the combustion field. He has contributed many articles to engineering societies and technical magazines, and is the author of two well-known books "Combustion in the Power Plant" and "How to Buy, Sell and Burn Coal."

Mr. Marsh is a life member of the ASME; and member and ex-chairman of the executive committee, Fuel Division of the American Society of Mechanical Engineers.

New Officers for DEMA

AT THE ANNUAL meeting of the Diesel Engine Manufacturers Association held on December 11 in Chicago, E. J. Schwanhausser, vice-president of Worthington Pump & Machinery Corp., was elected president. Gordon Lefebvre, president of Cooper-Bessemer Corp., and J. E. Peterson, vice-president of General Machinery Corp., were elected vice-presidents of the association. Robert H. Morse, Jr., vice-president and general sales manager of Fairbanks, Morse & Co., was elected treasurer. Harvey T. Hill, executive director of Diesel Engine Manufacturers Association, was likewise reelected to serve through 1946.

The new directors who were elected are A. W. McKinney, vice-president of the National Supply Co., and G. F. Twist, vice-president and general manager of the Atlas Imperial Diesel Engine Co. Those continuing on the Board of Directors from last year are George W. Codrington, vice-president of Feneral Motors Corp., Norris H. Schwenk, president of Busch-Sulzer Bros. Deisel Engine Co., Charles E. Brinley, Chairman of the Board, Baldwin Locomotive Works; Robert E. Friend, president of Nordberg Mfg. Co.; Mr. Schwanhausser, Mr. Morse and Mr. Lefebvre.

Herty New ASM President

THE AMERICAN SOCIETY FOR METALS at its annual meeting held the first part of November at the Cleveland Club, Cleveland, Ohio, elected Dr. Charles H. Herty, Jr., of Bethlehem, Pa., as the national president. Other officers elected were A. L. Boegehold, head of the metallurgy department, Research Laboratories Division, General Motors Corp., Detroit, vice president; Dr. H. K. Work, manager of research and development, Jones & Laughlin Steel Corp., Pittsburgh, treasurer; John Chipman, professor of metallurgy, Massachusetts Institute of Technology, Cambridge, Mass., and W. E. Jominy, chief metallurgist, Dodge Chicago Plant, Chrysler Corp., Chicago, trustees.

The meeting was presided over by the president of the last year, Dr. Kent R. Van Horn of Cleveland,

TUBE CLEANING PROBLEM solved by WILSON ECT AIR MOTOR

UP TO 40% MORE POWER WHILE "TAKING THE CURVES"

Negotiating a curve is one of the toughest jobs for tube cleaners. Naturally, a small diameter motor can "take the curves" easier than a larger one — but in building motors for curved tubes, power has often been sacrificed for small diameter.

Wilson Engineers tackled this important problem and after years of research, developed the ECT Series Air Motor, combining small size with greater power. Size-for-size, the ECT Series Air Motor has often developed up to 40% more power than ordinary motors.

and here's how . . .

Its six-bladed, light-bladed construction, together with exclusive automatic valving of operating air, gives you these advantages:

- **Higher torque at any speed *because six-blades produce a smoother flow of power . . . 12 powerful impulses per revolution.***
- **Less air consumption *with a minimum of back pressure, is obtained from automatic valving of operating air.***
- **Positive starting—*Six-blades eliminate the dead center . . . hard to stall.***
- **Less downtime *because up to 40% extra power helps you get your tube cleaning jobs done faster, more thoroughly with consequent savings in labor and lost production time.***

Diagram shows features of Wilson ECT Series Air Motor

Send for additional information on Wilson ECT Series Air Motors . . . or for the name of the Wilson representative nearest you. Address department N.

TW-702

THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N. Y.

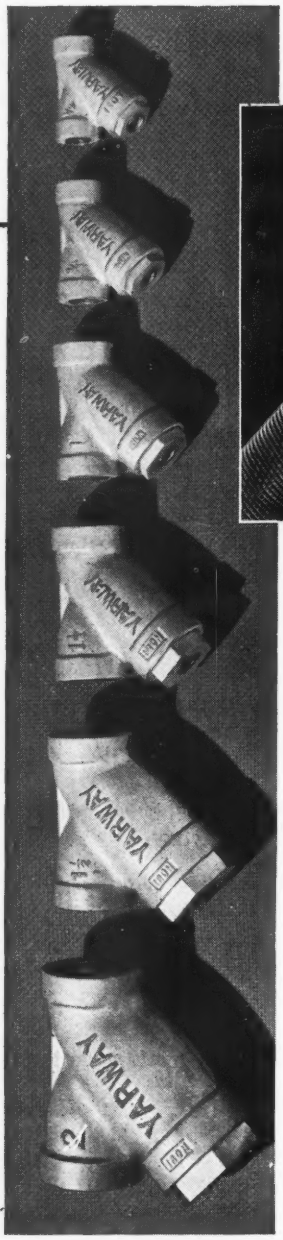
WILSON
TUBE CLEANERS

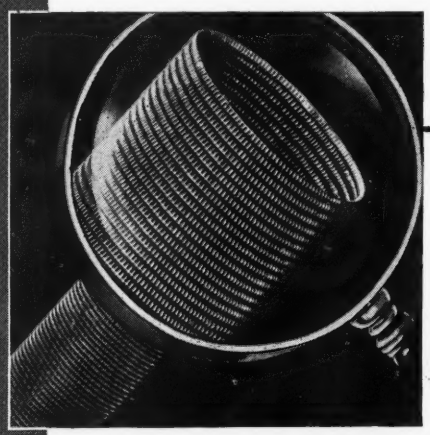
PREVENT

Rust · Scale · Dirt

FROM CLOGGING

STEAM EQUIPMENT





YARWAY

STRAINERS

"The Screen's the Thing"

- *A High Grade Monel Woven Wire Basket* with mesh fine enough to catch the dirt—yet ample free area for passage of clean condensate, oil and other fluids.
- *Body Cadmium Plated Inside and Out for Protection Against Corrosion.*
- *Readily Removed Steel Blow-Off Bushing.*
- *Bushing Automatically Aligns Screen.*
- *Thousands in Use—Sold by Over 100 Mill Supply Houses.*
- *6 Sizes ½" to 2" for Pressures up to 600 Lbs.*

See Your Supply House or write for Bulletin S-200

YARNALL-WARING COMPANY

114 MERMAID AVENUE PHILADELPHIA 18, PA.

YARWAY STRAINERS

Ohio. In addition to the election of officers the annual meeting included a report by W. H. Eisenman, national secretary of the Society, and the meeting was addressed by Dr. Herty who read a paper entitled, "Steel Making Practice as it Affects Properties of Interest to the User."

Officers Elected for ECPD

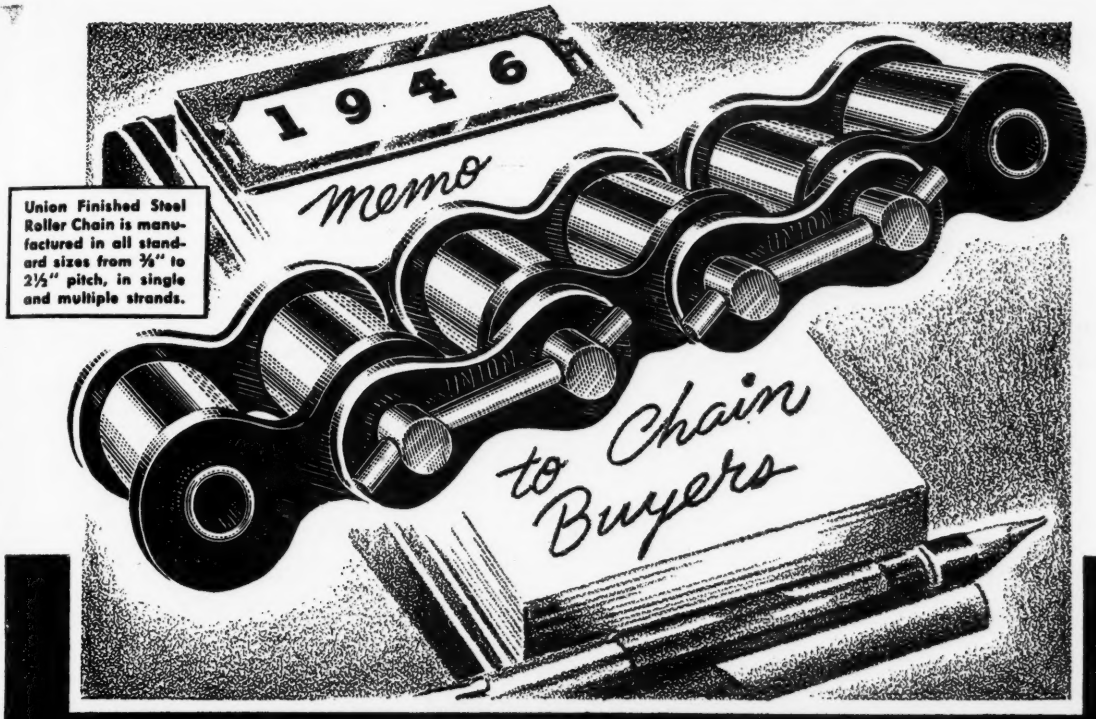
ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT which held its annual meeting in the Engineering Societies Building, New York City, on October 19 and 20, re-elected Everett S. Lee, engineer of the General Engineering and Consulting Laboratory, General Electric Co., Schenectady, N. Y., as chairman and James W. Parker, president, general manager, and director of The Detroit Edison Co., Detroit, Mich., was re-elected vice-chairman. Wm. N. Carey, Secretary and Executive Officer of the ASCE, and H. H. Henline, National Secretary, AIEE, were elected Secretary and Assistant Secretary respectively.

Engineer's Council for Professional Development has been formed of engineering organizations for the purpose of enhancing the professional status of engineers through co-operative effort. Its constituent organizations are: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, The Engineering Institute of Canada, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

Material Handling Society Formed

IN PITTSBURGH on October 8, a group of men interested in material handling voted to form a society whose objectives would be: 1. To further the application of good material handling practices; 2. To encourage an interchange of ideas among the members; 3. To promote education and training in the science and practice of practical co-ordinated material handling; 4. To arrange for the collection and dissemination of information relating to all phases of material handling.

Temporary officers elected were: chairman, T. O. English, Aluminum Co. of America; secretary, Richard Rimbach, Materials Publishing Co. The following committees were elected: program committee, Fred W. Bradley, National Adhesives Division of National Starch Products, Inc., chairman; Martin A. Lyons, Westinghouse Electric Corp., and E. L. Niederhofer, Chemical Plants Division, Blaw-Knox Co., members. Constitution committee, D. B. Hendryx, Harbison-Walker Refractories Co., chairman; Louis E. Dietrich, P. Duff and Sons, and Jay Overpeck, J. H. Overpeck Co., members. Nominating committee, F. Gordon Ricker, Yale & Towne Manufacturing Co., chairman; Samson A. Huey, P. Duff and Sons, and James M. Phillips, Phillips Mine and Mill Supply Co., members. Mem-



Union Finished Steel Roller Chain is manufactured in all standard sizes from ⅜" to 2½" pitch, in single and multiple strands.

A BETTER YEAR TO BUY UNION CHAIN

☆ First, because Union had no reconversion problems, and now has a greater portion of production capacity devoted to manufacturing chains for peacetime tasks of power transmission and the handling of materials.

Second, because Union made major improvements in equipment and processes in order to manufacture chains equal to the demands of rigorous military usage and is now applying those advancements to its regular manufacture of Machine Finished Roller Chain and Sprockets, Silent Chain and Sprockets and Engineering Class Chain and Sprockets. These two advantages coupled with the plus value which has always resulted from Union's Specialization in the field of chain manufacturing make 1946 the best year you have ever had to buy Union Chain. Want proof? Just send us your orders!

The Union Chain and Manufacturing Company ..... Sandusky, Ohio, U. S. A.

Union Chains for Every Application

Drive and Conveying Chains and Sprockets
- Bridge Chain
- Combination Malleable Iron and Steel Chain
- HB (hardened bearing) type chain
- BP (bar and pin) type chain

★

Finished Steel Roller Chains and Sprockets
- All manufacturer's standard sizes ⅜ in. to 2½ in. pitch
- Single and Multiple Strands
- Extended Pitch Series in sizes 1¼ in. to 4 in. pitch

★

Silent Chain and Sprockets
- All sizes ⅜ in. to 1½ in. pitch

★

Flexible Couplings
- Roller chain type
- Silent chain type

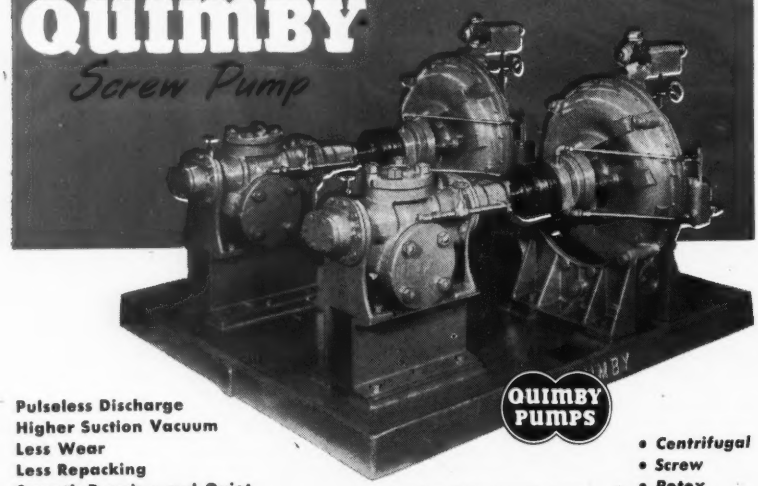
Catalog A-2 covers Drive and Conveying Chain. B-2 covers Finished Steel Roller Chain. FC-1 covers Flexible Couplings. Ask for your copies.

ARMY ★ E ★ NAVY

UNION CHAINS

You can burn it *Better* and *Cheaper* with a

QUIMBY
Screw Pump



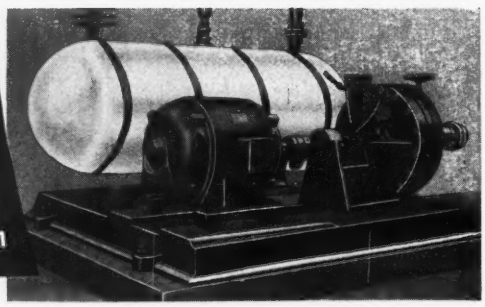
Pulseless Discharge
Higher Suction Vacuum
Less Wear
Less Repacking
Smooth-Running and Quiet
Motor or Turbine Drive

Dual turbine-driven pumping set
6 HP, 1450 RPM, 15 GPM.

- *Centrifugal*
- *Screw*
- *Rotex*
- *Sump*

H. K. PORTER COMPANY, Inc.
PITTSBURGH 22, PENNSYLVANIA
QUIMBY PUMP DIVISION
340 THOMAS STREET, NEWARK 5, N. J.

Increase
YOUR PRODUCTION
with the
STOUT NO-VENT
Boiler Return System



—for Cookers, Heaters, Driers, etc.

It operates continuously returning condensate, ALL OF IT, fast as formed and at the same pressure and temperature at which it leaves the steam heated units. Air and non-condensibles are then automatically removed and the condensate, in the form of distilled water, returned direct to boiler. There are no traps or orifices in the system.

High temperature direct return saves fuel. Often 25% or more. (This would offset the 20% cut expected in soft coal deliveries to industry as announced July 14th by Secretary Ickes.)

Improved circulation the Stout NO-VENT way uniformly increases the temperature in steam heated units and increases production. Reducing boiler load and returning distilled water prolongs boiler life.

If you operate steam heated cookers, heaters, driers, ironers, clothing presses, drying ovens, oil tanks, water tanks, pickling tanks or have other uses for so-called "process steam" investigate the Stout NO-VENT Boiler Return System. It can boost your production.

DAVID STOUT & SONS • 6 N. Michigan Ave. • CHICAGO 2, ILL.
Heat Reclaimers • Steam Condensers • Spiro Water Heaters • Gas Fired Boilers

Stout
NO-VENT BOILER RETURN SYSTEM

Write for bulletin showing hookup of Stout NO-VENT System and giving operating details. Made in capacities 100 to 800 bhp, pressures to 200 lb. Distributors will be interested in selling franchise.

bership committee, Fred Benjamin, Kress Box Co., chairman; O. Heidenreich, Elwell-Parker Electric Co., and J. L. Logan, Hagan Corp. members.

Business Research Sponsored by Commonwealth Edison

THE COMMONWEALTH EDISON group of companies has announced the appointment of Milburn L. Forth as industrial economist to head up the research activities of their recently created territorial information department in Chicago.

The new department, staffed with statisticians, industrial specialists, tax analysts, and other business experts, will assemble and make available factual data about Chicago and Northern Illinois as an aid to business, industry and agriculture. It will gather data on taxes, transportation, markets, labor supply, residential construction, raw materials, industrial production, distribution and other factors having a bearing on industrial development of the area.

Associated with Commonwealth Edison Co. in sponsorship of the new program are: Public Service Co. of Northern Illinois, Western United Gas and Electric Co. and Illinois Northern Utilities Co. The sponsoring group supplies electric service in Chicago and both electric and gas service in a territory embracing nearly 11,000 sq mi extending from Chicago across Northern Illinois.

MANUFACTURERS' *News*

Worthington Plans Manufacturing at Holyoke

PLANS ARE NOW complete to turn a large part of the heavy ordnance manufacturing facilities of the Worthington Pump and Machinery Corporation's Plant in Holyoke, Mass., into production of air conditioning and refrigeration equipment of the latest design. Facilities for the operation have been moved there from the corporation's plant in Harrison.

Engineers are concluding designs for a new line of Freon-12 refrigerating compressors. Also to be produced at Holyoke will be a line of air handling equipment including air conditioning units, shower condensers, product coolers, and evaporative coolers in a wide range of sizes and capacities.

One of the most complete test laboratories for refrigeration equipment in the country has been installed. Assembly line methods have been set up in the same shop where 90 mm antiaircraft guns were produced in the early part of the war.

Sales headquarters will also locate in Holyoke. The heavy equipment is still being made in Harrison.

MAKE THIS TEST *for swelling...*

Take one of your present pump valves . . . and a Sea-Ro 535 (see below)* . . . soak them together in boiling water for 24 hours. Then just put the micrometer on each one — *and get set for a shock!* For the amazing resistance to swelling of Sea-Ro 535s is something you'll have to *compare with your own eyes* — to believe.

Sea-Ro 535 is a laminated phenolic-base general purpose valve. It is custom-made to handle all liquids, temperatures, pumping equipment — normally found on sea-going vessels. Sea-Ro 535s *release* the bronze vitally needed for war. Sea-Ro 535s last longer, reduce up-keep costs, treat valve seats gently.

**SAMPLES FREE: You are invited to make this test yourself . . . without incurring any obligation whatever. Write today for Free Samples, to: Sea-Ro Packing Co., Wood Ridge, N. J.*

SEA-RO MARINE PUMP VALVES

SEA-RO

-resist swelling

SEA-RO NEK-SEAL PACKING
SEA-RO PUMP PLUNGER RINGS

Machined from Drop Forgings

For Greater Safety and Reliability

Forged— to withstand strains of expansion and contraction under wide temperature ranges.

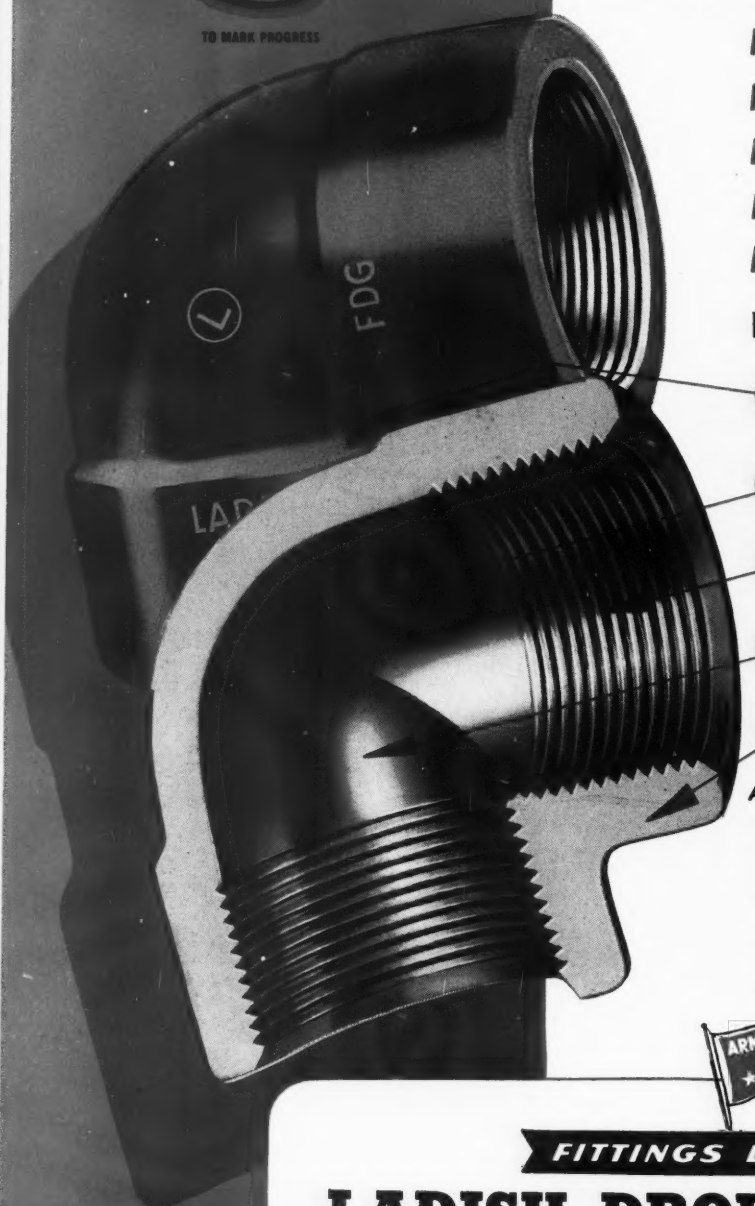
Forged— to resist fatigue failures under the strains of vibration.

Forged— for maximum strength to withstand hydraulic shock pressures.

Forged— to eliminate possibility of concealed physical defects.

Forged— under metallurgical controls that assure weldability.

TO MARK PROGRESS



Ladish Features that Assure Reliability

1. Ladish forged steel fittings bear the symbol of Controlled Quality—the Ladish Heat Code.
2. Uniform wall thickness achieved by [illegible] machining provides [illegible] safety factor.
3. Full, clean-cut threads, or deep sockets on socket-welding types assure pressure-tight joints and easier piping [illegible].
4. Smooth bored to assure minimum resistance to flow.
5. Thick bands and controlled grain flow provide maximum strength and fatigue resistance.

Available in:

Carbon Steel—Conforming to ASTM A105, Grade II.

Carbon-Molybdenum Steel—Conforming to ASTM A-182, Grade F1.

Chromium-Molybdenum Steel (4-6 Chrome)—Conforming to ASTM A182, Grade F5.

Chromium-Nickel (Stainless) Steel (18-8)—Conforming to ASTM A182, Grade F8.

Special materials to order.

ARMY E NAVY

FITTINGS DIVISION

LADISH DROP FORGE CO.

CUDAHY • WISCONSIN (MILWAUKEE SUBURB)

District Offices: NEW YORK • PITTSBURGH • CLEVELAND • ST. LOUIS • HOUSTON • LOS ANGELES

LADISH
CONTROLLED QUALITY

FORGED STEEL FITTINGS CATALOG NOW AVAILABLE

SECTION I—SCREWED FITTINGS
Full depth thread, accurately cut, results in pressure-tight joints. Pipe enters easily. Uniform thickness. Sizes clearly marked . . . ⅛" through 4". 2000—3000—6000 pound. Carbon—Alloy—Stainless.

SECTION II—SOCKET WELDING FITTINGS
Speed up installation because deep sockets save time formerly required to cut pipe to exact length. Socket supports pipe and allows self-alignment. No machining of pipe necessary for fit. ASSURED WELDABILITY. Sizes clearly marked . . . . ⅛" through 4". 2000—3000—4000—6000 pound. Carbon—Alloy—Stainless.

SECTION III—TECHNICAL DATA
44 pages of diagrams, pressure ratings, specifications and technical data.

The Ladish Fittings Catalog Volume 2 has been carefully compiled by Ladish engineers to assist you in selecting the right fittings for your needs. Write for your copy today.

THAT AIN'T EVEN GOOD APPLE-POLISHING
LET THE SUCKER TALK! HE'LL WISH HE HAD A ZIPPER IN HIS MOUTH BEFORE HE'S THROUGH!
I ALWAYS SAID YOU GOT WHAT IT TAKES TO RUN A PLANT LIKE THIS, BOSS...
IF HE REALLY WANTS TO BALLOON THE OLD BOY, WHY DON'T HE TALK ABOUT RAINBOW?
YEAH, OLD SCOWL-FACE THINKS MORE OF RAINBOW THAN OF HIS WIFE AND KIDS!
YOU AIN'T KIDDING BROTHER, THE OLD MAN TALKS ABOUT A WELL-PACKED FLANGE AS IF IT WAS A PIN-UP GIRL!
I'LL TAKE THE PIN-UP GIRLS, MYSELF!

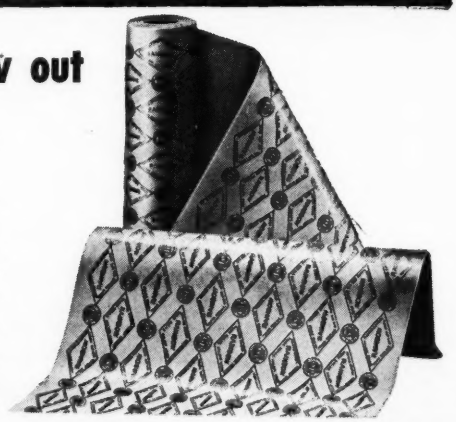
RAINBOW will not squeeze out or blow out

Maybe that's old stuff to you. For Rainbow has been a familiar packing word for 56 years.

It's the original Red Sheet Packing, specially compounded for packing flanges and other parallel surfaces. It can be successfully used against hot or cold water, air, saturated steam pressures, and for hydraulic conditions.

Rainbow has the firmness to insure leak-proof joints, plus the resilience to compensate for vibration, contraction and expansion in the line. It will neither squeeze nor blow out of a joint.

Serving Through Science with Mechanical Packings for all Industry



Listen to "Science Looks Forward"—new series of talks by the great scientists of America—on the Philharmonic-Symphony Program. CBS network, Sunday afternoon, 3:00 to 4:30 E.S.T.

UNITED STATES RUBBER COMPANY

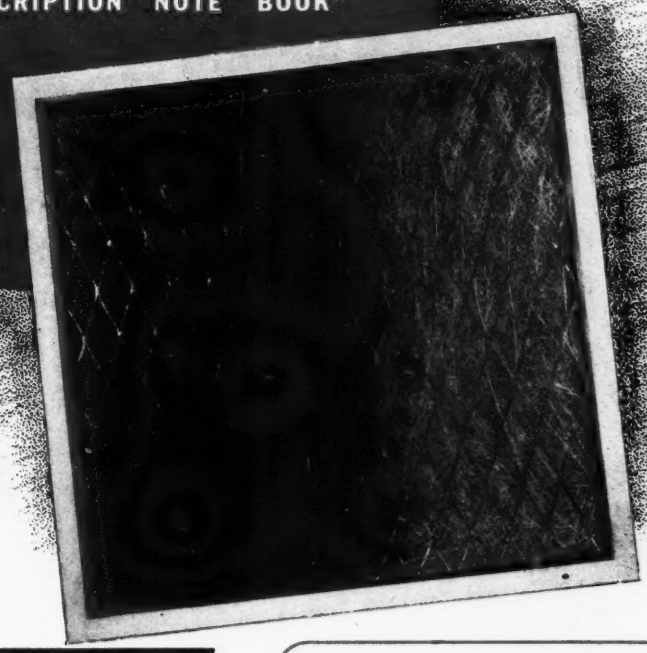
Serving Through Science

1230 AVENUE OF THE AMERICAS • ROCKEFELLER CENTER • NEW YORK 20, N. Y.

PAGE 1

OAKITE "PRESCRIPTION NOTE BOOK"

ONE OF A SERIES of data sheets for power plant engineers outlining various Oakite maintenance and equipment cleaning tasks. Each sheet may be filed for reference to serve as a reminder for obtaining more specific information.



Cleaning Washable Type AIR FILTERS

FREQUENT cleaning of dry or viscous washable-type air filters is recommended to assure full filtering capacity. Operating conditions, dust load, type of impinged soil, adhesive and other deposits to be removed, including equipment available, generally determine the Oakite material and method recommended. Additional factors are whether filter mats are ferrous or non-ferrous metal or are fabricated from glass wool, spun glass or similar material.

Oakite Alkaline, Acidic and Solvent Materials Designed For Filter Cleaning

Whatever the type of air filter employed in your air conditioning equipment, the successful experience of Oakite Technical Service Representatives can prove valuable and helpful to you in handling this work on a low-cost, efficient basis. Moreover, from among the wide range of Oakite alkaline, acidic and solvent type materials at his command, there is one that will effectively and safely remove the great variety of deposits generally encountered in air filters, including slime, mold and lime scale. Write us today . . . we are at your service.

Other Power Plant Cleaning Jobs for OAKITE

Automatic Filters . . . Electrical Precipitators . . . Controlling Slime and Scale Formation in Air Wash Air Conditioning Units . . . Cleaning Evaporative Condenser Coils . . . Controlling Slime and Mold in Humidifying Systems . . . Cleaning and Descaling Diesel or Gasoline Engines . . . Cleaning and Descaling Jacket Water Coolers and Lube Oil Coolers . . . Cleaning Surface Condensers . . . Cleaning Water and Steam Condensate Meters . . . Descaling Water Cooled Compressors . . . Cleaning Unit Heaters . . . Descaling Ammonia Condensers . . . Cleaning Transformers . . . Cleaning Painted Surfaces of Equipment . . . Stripping Paint . . . Cleaning Floors.

NOTE: The Oakite Technical Representative in your locality is ready to give you the benefit of his experience and personal help on any power plant cleaning or related problem. This Advisory Service is free.

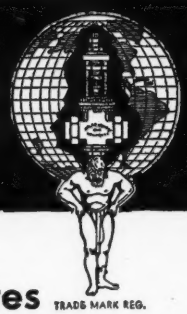
OAKITE PRODUCTS, INC. 23 Thames Street New York 6, N. Y.

Technical Service Representatives in All Principal Cities of the United States and Canada

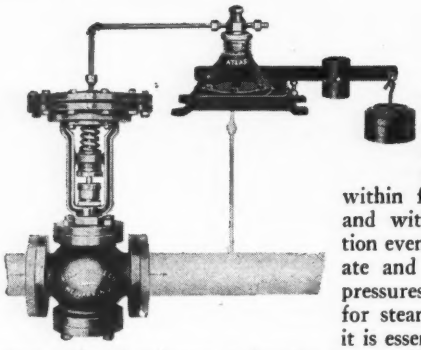
OAKITE *specialized cleaning*

MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

ATLAS
Super-Sensitive
PRESSURE REGULATORS



maintain controlled pressures TRADE MARK REG. **without variation—regardless of fluctuations in demand or varying initial pressures**



This ATLAS Super-Sensitive Regulator is particularly adapted to service where pressures must be maintained within fractions of one pound and without perceptible variation even where demands fluctuate and widely varying initial pressures occur. It is suitable for steam, air, gas, etc., where it is essential to maintain a constant reduced pressure in heating mains, vats, cookers, retorts, etc. It may also be applied as an altitude regulator to maintain constant level in open tanks, or as a pump governor to assure constant pump discharge pressure.

The scope of applications of this ATLAS Regulator is almost unlimited in pressure regulation. It will accurately regulate at any pressure between the initial pressure and atmosphere in one stage, operating control valves from ½" to 6".

Write for Bulletin No. 1B
Giving Complete Details

No. 801—for reduced pressures 2 to 15 lb.
No. 801-8—for reduced pressures 0 to 5 lb.
No. 802—for reduced pressures 15 to 150 lb.
Sizes ½", ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 5", 6".

Check the items below on which you want complete information and mail to us with your name, firm name and address.

PRINCIPAL ATLAS PRODUCTS

- ☐ Super-sensitive Pressure Regulators
- ☐ Other Pressure Regulators
- ☐ Damper Regulators
- ☐ Temperature Regulators
- ☐ Reducing Valves
- ☐ Exhaust Control Systems
- ☐ CAMPBELL Boiler Feed Water Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Oil Control Cocks
- ☐ Humidity Controllers
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE

Specialists in Regulation for Nearly a Half Century
291 South St., Newark 5, N. J.
Representatives in Principal Cities

Briggs Filtration Company

THE BRIGGS FILTRATION CO., a Maryland corporation, has acquired the business of the Briggs Clarifier Co., a manufacturing enterprise founded in 1933 by Chase Donaldson. Officers of the new company, all of whom have served with the old company, are Chase Donaldson, president; S. W. Briggs, vice president; R. C. Zschiegner, treasurer; W. E. Furey, secretary-counsel; Cecil Hopkins, assistant secretary.

The Briggs Filtration Co., which owns all patents, processes and trade names, will continue to design and manufacture the extensive line of oil filters which have been the product of Briggs Clarifier Co. All the activities of the company will be conducted from the two modern plants at River Road and the B. & O. tracks in Maryland which were acquired during the war.

The line will be widened by the addition of new types of ceramic screens and binders for foundries. The Briggs Clarifier, which has been used broadly in the Diesel, automotive, maritime, railroad and aviation fields, has undergone improvements in design simplifying its operation, and additional types of refills have been designed to meet economically all oil filtration needs.

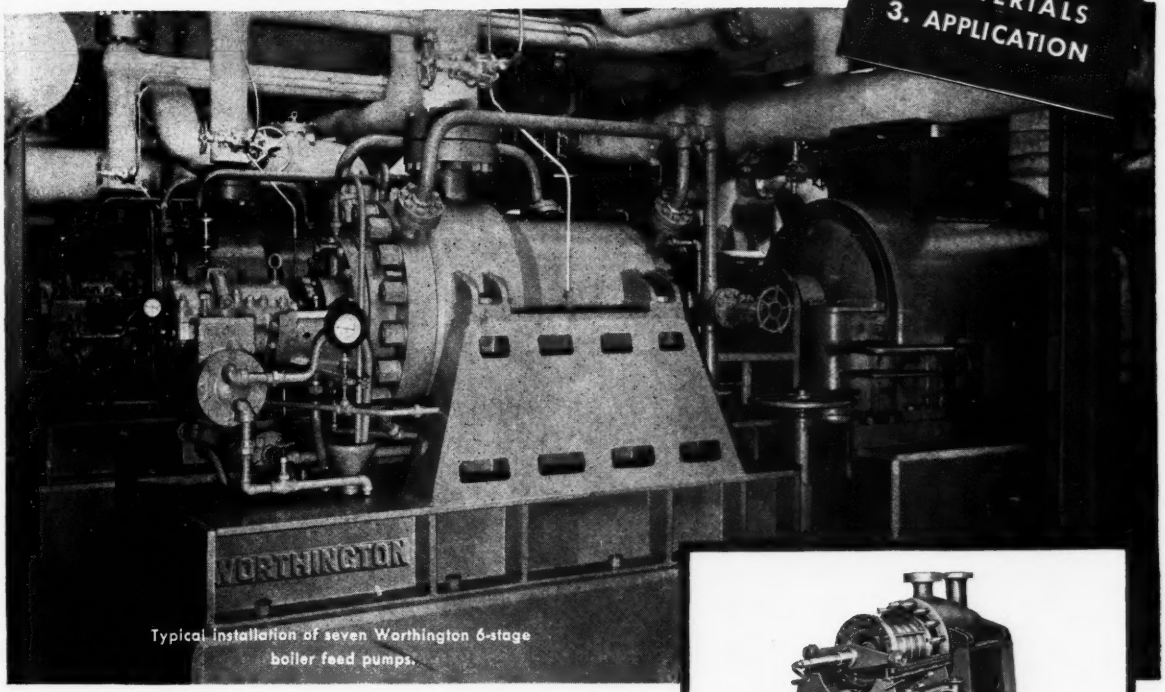
MANUFACTURERS' *Personals*

Robert M. Hatfield has recently become Assistant General Sales Manager of Combustion Engineering Co., having resigned as Deputy Vice Chairman of the War Production Board. Mr. Hatfield graduated with the class of 1932 from Purdue University with a mechanical engineering degree and became associated with Combustion Engineering Co. in 1984 as a student engineer, subsequently serving in the Service and Erection Department, the Proposition Department and then as sales engineer in the Cleveland offices. In 1942 he became associated with WPB where later he became director of the Production Scheduling Division. He accepted a commission in the Navy in May, 1944, and in November of that year was assigned back to WPB to take charge of the Navy repair parts program, where he became Deputy Vice Chairman for Production of WPB, which position he held until this board was abolished on November 2.

Announcement has recently been made by Yarnall-Waring Co. of Philadelphia of the following personnel changes: Joseph Kildare has been appointed sales manager with offices in Philadelphia; Frank W. Miller has been made works manager at the factory, and J. Frank Long has been transferred to the Chicago district office from the Philadelphia office as sales engineer. Charles H. Grosjean, sales engineer in New York office, is now in charge of the Detroit sales office, replacing C. N. Maxfield, who

WHY WORTHINGTON HIGH-PRESSURE PUMPS *excel in all three . . .*

1. DESIGN
2. MATERIALS
3. APPLICATION



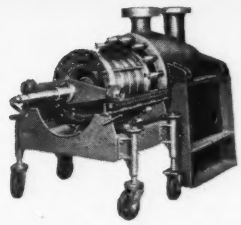
Typical installation of seven Worthington 6-stage boiler feed pumps.

1. DESIGN—Worthington has longer experience in manufacturing high-pressure centrifugal boiler feed pumps . . . has acquired unique constructive ideas from power-plant operating engineers. That's why you'll find such superior design features in Worthington high pressure boiler feed pumps as: a balancing device construction that minimizes wear; bolted ring-type pressure joints; impellers shrunk on the shaft; oversized Kingsbury thrust bearings.

2. MATERIALS—Worthington has greater facilities for research. That's why you'll find the *right* materials in Worthington high-pressure boiler feed pumps: stainless steel for internal parts—to prevent destructive corrosion and erosion; forged steel casings—tested and proved by years of power plant operation.

3. APPLICATION—Worthington Pump Application Engineers are thoroughly versed in every phase of applying the most complete line of boiler feed pumps for high or low pressures — capacities from 50 to 3500 GPM . . . pressures from 50 to 2500 PSI. That's why Worthington will fit the *right* feed pumps to your feed cycle.

For further details on Worthington High-Pressure Boiler Feed Pumps . . . or for an appointment with a Worthington P.A.E.*, write us or telephone the nearest of our 36 district offices. You'll find



AS EASY TO DISMANTLE AND ASSEMBLE AS A SPLIT-CASE PUMP

Complete rotor assembly of Worthington High-Pressure Boiler Feed Pump can be withdrawn *in one piece* on a portable assembly truck without disturbing suction or discharge piping connections. Simplifies inspection, replacement or repair of internal parts.

that *there's more worth in Worthington. Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N.J.*

*Pump Application Engineer

WORTHINGTON

THE WORLD'S LARGEST MANUFACTURER OF PUMPS

For Boiler Feed Service
Capacities from 30 to 1500 g. p. m. Heads from 180 to 1000 feet.

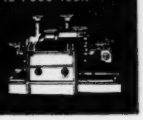
For Hotwell, Condensate, Chilled Water, General Service
Capacities from 150 to 1300 g. p. m. Heads from 110 to 500 feet.

For Boiler Feed Service
Capacities from 25 to 1450 g. p. m. Heads from 220 to 1600 feet.

For Water Works, Circulation, Drainage, General Service
Capacities from 500 to 1600 g. p. m. Heads 900 to 3200 feet.

For Boiler Feed Service
Capacities from 200 to 1600 g. p. m. Heads from 900 to 3200 feet.

For Boiler Feed Service
Capacities from 500 to 3000 g. p. m. Heads from 2000 to 7000 feet.



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✓ A CLEANER PLANT...

✓ A SAFER PLANT...

✓ A MORE PRODUCTIVE PLANT...

✓ A MORE PROFITABLE PLANT

Hoffman vacuum cleaning equipment is the economical solution to cleaning up coal dust and ash deposits. Hoffman has specialized for many years in power plant cleaning problems: Hoffman is standard equipment in many large power companies. A Hoffman stationary system — or heavy duty portable cleaner — accomplishes a more thorough cleaning job with less work, improves plant conditions, and prevents frequent repairs to many delicate instruments.

CALL HOFFMAN FOR THE RIGHT ANSWER TO EVERY DUST CONTROL PROBLEM . . .

★ SEND FOR LITERATURE ★

U. S. HOFFMAN MACHINERY CORPORATION

AIR APPLIANCE DIVISION, 101 FOURTH AVE., NEW YORK 3, N. Y.

has been appointed California district manager with new sales offices in San Francisco and Los Angeles. Jackson Kemper has been added to the Yarway sales force in the New York office, and Jack Schuyler takes up a general position in the Los Angeles office.

Saverite Engineering Co. of Los Angeles has recently appointed A. K. Granrud as a district representative. Mr. Granrud has served with the Red River Lumber Co., as a commissioned boiler inspector with the Hartford Steam Boiler Inspection and Insurance Co., and as operator of various industrial and utility power plants in California.

Baldwin Locomotive Works has announced that B. A. Springer, hydraulic press and power tool engineer, has become sales engineer for the company and will be with the Chicago office of the Southwark Division of Baldwin, specializing in hydraulic presses.

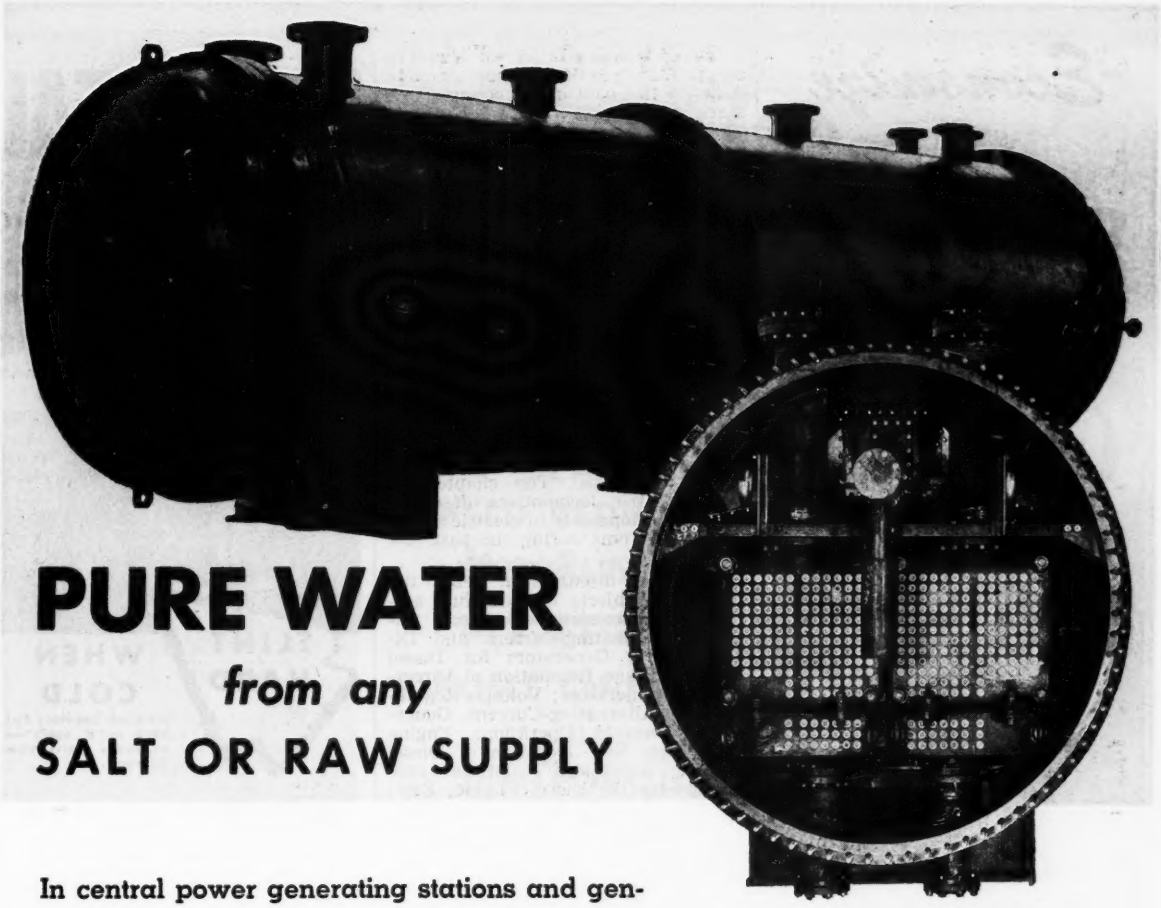
A. M. Stephenson, an engineer in the Cleveland service department of Iron Fireman Manufacturing Co. since 1942, now is district representative with headquarters at Charlotte, N. C. A. Bayes Jordan takes the place of S. W. Alford, southern division district representative, who has been promoted to district sales manager. Mr. Jordan has had several years of experience with a large southern utility and more recently as industrial sales engineer for a leading producer of insulation material.

Blackmer Pump Co. has announced that Lt. A. C. Nydegger, USNR, recently relieved of active duty from the Navy, has rejoined the company and will be manager of the Milwaukee office at 1127 N. Van Buren St. Mr. Nydegger served as an engineering officer and had attained the rank of lieutenant senior grade.

New ENGINEERING BOOKS

Diesel-Electric Plants. By Edgar J. Kates. Copyright 1945, Second Edition; 6 by 8½ in.; 272 pages; 170 illustrations; cloth cover; published by the American Technical Society, Drexel Avenue at 58th Street, Chicago 37, Illinois; price $3.75.

As explained when the first edition of this book was published in 1936, its principal objective was to deal with the co-ordinated aspects of the Diesel-electric plant, rather than with the separate subjects of electrical equipment by itself and Diesel engines as engines. Both of these have had adequate treatment in other textbooks. However, as the author pointed out at that time, in Diesel-electric plants the electric equipment is greatly influenced by the characteristics of the Diesel engine. In the first edition, the construction, operation, and maintenance features, were particularly stressed and the aim was to discuss the subject for the man without a college education.



PURE WATER

from any

SALT OR RAW SUPPLY

In central power generating stations and general industrial plants . . . on naval and commercial vessels . . . in refineries and chemical process plants . . . wherever pure water is required for boiler feed make-up, process work, or general services . . . G-R Evaporators have established records for dependable, economical operation. These units do not require hand-scaling, and can be maintained by unskilled labor. Varying raw water conditions do not affect the product under wide limits. The distillate produced meets the exacting purity requirements of present day practice.

THE GRISCOM-RUSSELL CO., 285 Madison Ave., New York 17, N. Y.

Look into this G-R BENTUBE EVAPORATOR

Note the rugged construction, unusually large clearances, and widely spaced tubes. The heating surface of this unit consists of patented scale-shedding Bentube elements. Temperature variations change the curvature of the tubes, thereby shedding the scale. G-R Bentube Evaporators can be furnished for large or small capacities, and in single or multiple effects for any requirements.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

Economize WITH POWERS

TEMPERATURE REGULATORS

Use a Powers No. 11 Temperature Indicating Regulator when you want the advantages of an easy-to-read dial thermometer combined with a dependable self-operating regulator. The dial thermometer gives a visual check on the performance of the regulator and makes it easy to adjust for the required operating temperature. Various dials and ranges are available.

Is Easy To Install—because both the thermometer and the regulator operate from the same thermal system—only one tapped opening is required.

Write for Circular 2511

THE POWERS REGULATOR CO.

2746 Greenview Avenue, Chicago 14, Illinois
231 E. 46th St., New York 17, N. Y.—Offices In 47 Cities . . . See your phone directory.

70

OVER 50 YEARS
OF AUTOMATIC TEMPERATURE AND HUMIDITY CONTROL

In this second edition, the chapters on voltage regulation now include data on the new quick acting rheostatic type regulator, the electronic types, and the simple vibrating types. Automatic synchronizing using simple and inexpensive apparatus has come in to wide use and is fully discussed in the chapter on parallel operation.

The chapter on engine governors has been largely rewritten to cover the many forms of hydraulic governors now in use as well as the improved mechanical governors. Governor developments such as "Synchrophasing" and "Auto-load" are also discussed.

The chapter on automatic controls and alarms for the Diesel engine has been greatly enlarged to include many specialized problems and discussion of new devices, as well as typical hook-ups. The chapter on Diesel-electric locomotives describes recent developments in electric transmission systems during the past few years.

The book discusses in detail the following subjects in individual sections: Characteristics of Diesel Engines; Alternating-Current and Direct-Current Generators for Diesel Drive; Voltage Regulation of Direct-Current Generators; Voltage Regulation of Alternating-Current Generators; Parallel Operation; Engine Governors; Self-Operation of Diesel Plants; Automatic Controls and Alarms for the Diesel Engine; Electric Starting of Diesel Engines; Starting and Stopping Generators and Voltage Regulators; Installation and Maintenance of Generators and Voltage Regulators; Diesel-Electric Locomotives. A detailed index is provided.

Machine Tool Guide. By Tom C. Plumridge, Roy W. Boyd, Jr., and James McKinney, Jr. Copyright 1945; 8½ by 11 in., 630 pages; illustrated; cloth cover; published by American Technical Society, Drexel Avenue at 58th Street, Chicago 37, Illinois; price $7.50.

This book is a collection of detailed illustrations, drawings, specifications and complete technical details of all makes of automatics, boring machines, broaching machines, contour machines, drilling machines, duplicators, gear cutters, grinders, hobbing machines, lathes, milling machines, planers, presses, shapers, slotters, tapping machines and special material. While a great deal of the equipment described is of primary interest to engineers in industrial production, nevertheless a large amount of it is of the type used by power and industrial engineers in repair and maintenance work.

The information contained in this guide has always been more or less available in some form in the individual service manuals and catalogs of the various machine tool manufacturers. By bringing it all together in one volume the authors have performed the same function for this field that is performed by various mechanical, chemical and other catalogs in their field. This is the first time this has been done for machine tools and it would seem that the guide should be very useful to engineers in selecting such equipment for specific purposes.

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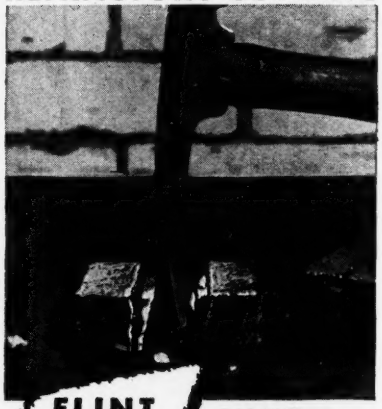

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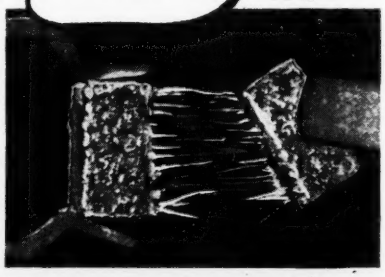

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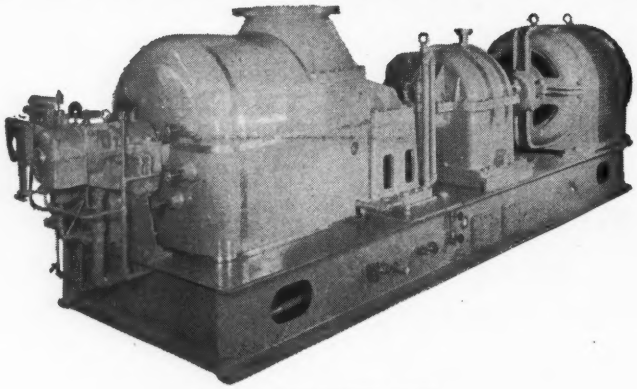

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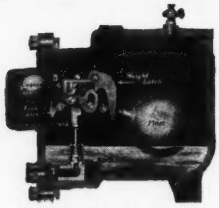

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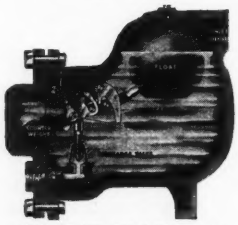

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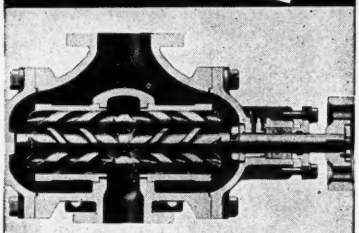

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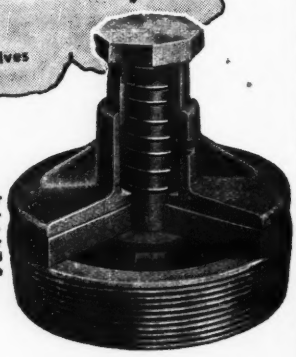

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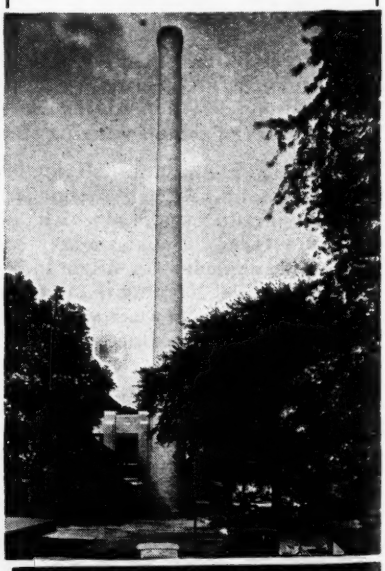

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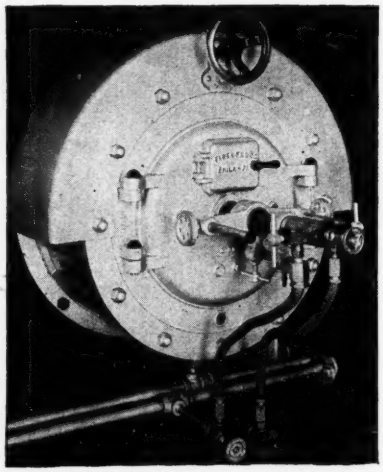

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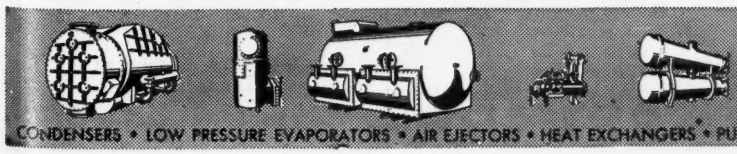

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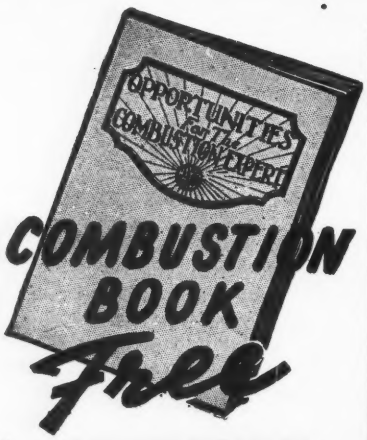

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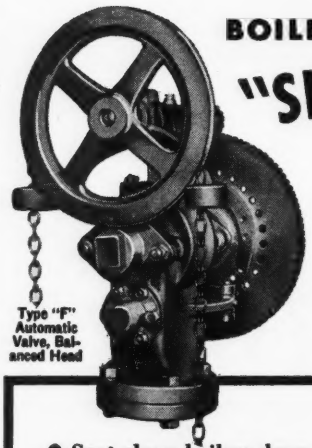

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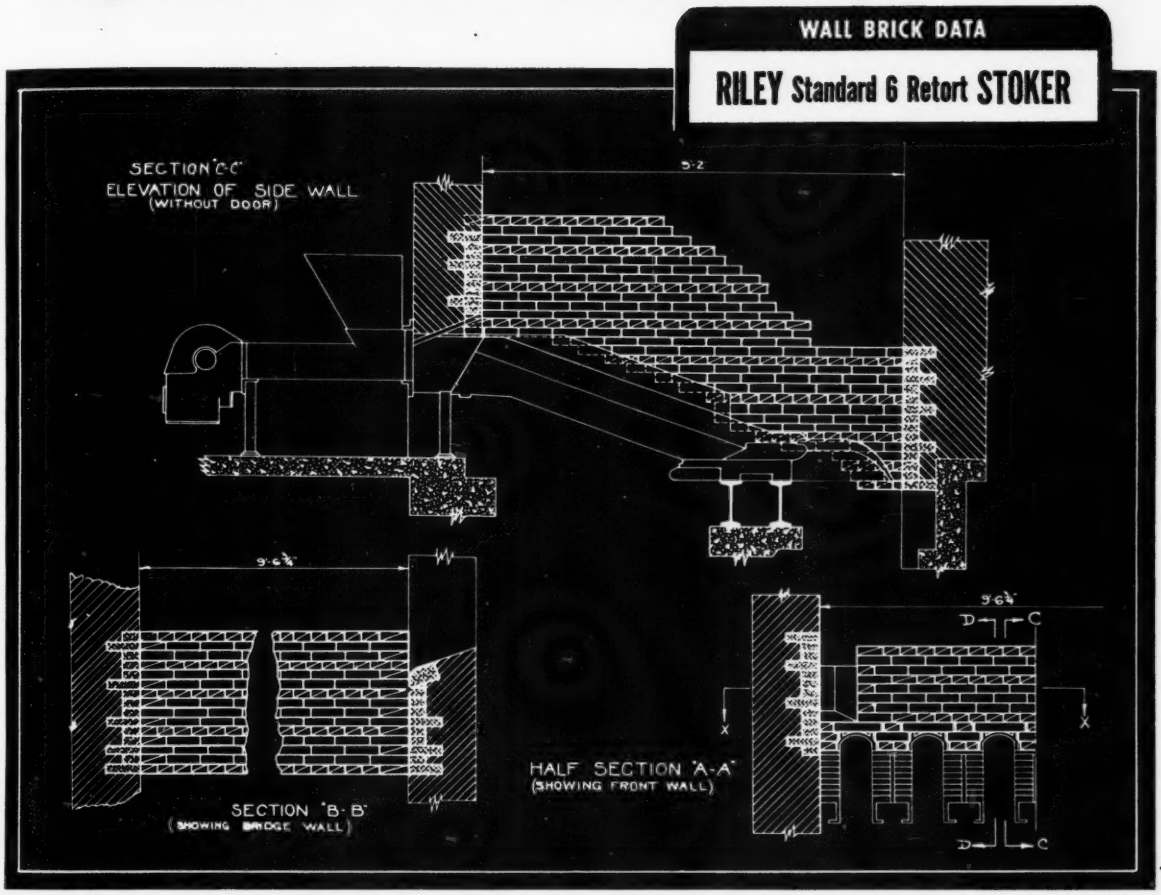

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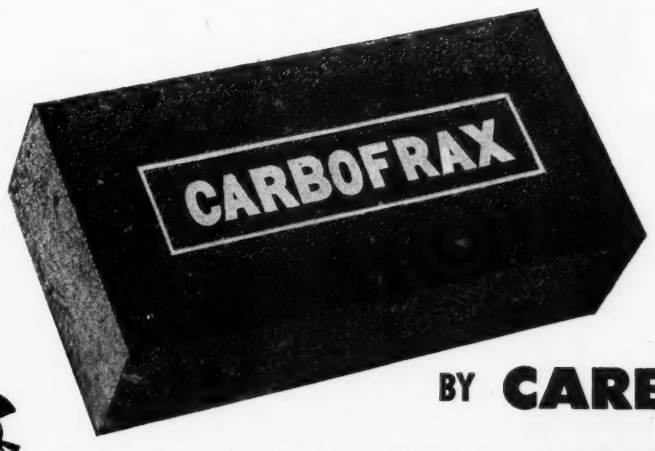

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POWER PLANT Construction News

Calif., Los Angeles—Continental Can Co., 3820 Union Pacific St., Los Angeles, plans installation of electric power equipment in new plant on East 50th St., for paper container division. Tract of land has been acquired, with existing two-story building, 120,000 sq. ft. floor space, to be remodeled and equipped at early date; new one-story addition will be built, approximately same floor area, as well as other buildings. Entire project will cost about $1,500,000. Main offices are at 100 East 42nd St., New York, N. Y.

Calif., San Diego—San Diego Gas & Electric Co. 861 Sixth Ave., has plans maturing for expansion in local Silver Gate steam-electric generating station, including addition to building and installation of new turbine-generator and auxiliary equipment for increased capacity. Extensions will be made in transmission and dstributng lines. Cost reported about $5,000,000.

Fla., Moore Haven—Geddes Electric Cooperative, Inc., Moore Haven, has approved plans for new power plant for power supply for rural electric system. Cost reported over $200,000 with equipment. It is understood that Diesel engine-generator units will be installed.

Fla., Ocala—Florida Power Corp., St. Petersburg, Fla., has approved plans for extensions in power plant in vicinity of Ocala, reported to cost close to $250,000 with equipment. Capacity will be increased. Extensions will be made in transmission lines in same area.

Ga., Savannah—Robert Gair Co., Inc., 155 East 44th St., New York, N. Y., corrugated boxes and containers, has plans under way for new pulp mill and paper board mill at Port Wentworth, near Savannah. It will comprise several large multi-story buildings, with machinery and electric power equipment for heavy output. A power house is planned. Cost estimated close to $9,000,000. It is understood that project will be carried out during 1946. J. E. Sirrine & Co., 215 Main St., Greenville, S. C., are consulting engineers.

Ill., Peoria—Babst Brewing Co., 221 North La Salle St., Chicago, Ill., plans installation of electric power equipment in new plant at Peoria Heights, comprising a seven-story brew-house, 89 x 135 ft., and four-story adjoining structure, 86 x 136 ft. A boiler house is planned. Entire project reported to cost over $750,000. Harley, Ellington & Day, Stroh Bldg., Detroit, Mich., are architects.

Ill., Springfield—Water, Light & Power Dept., is having plans completed for proposed extensions and improvements in municipal steam-electric power plant, known as Lake Side Station, with installation of new turbine-generator and auxiliary equipment for increased output. Cost reported over $2,700,000.

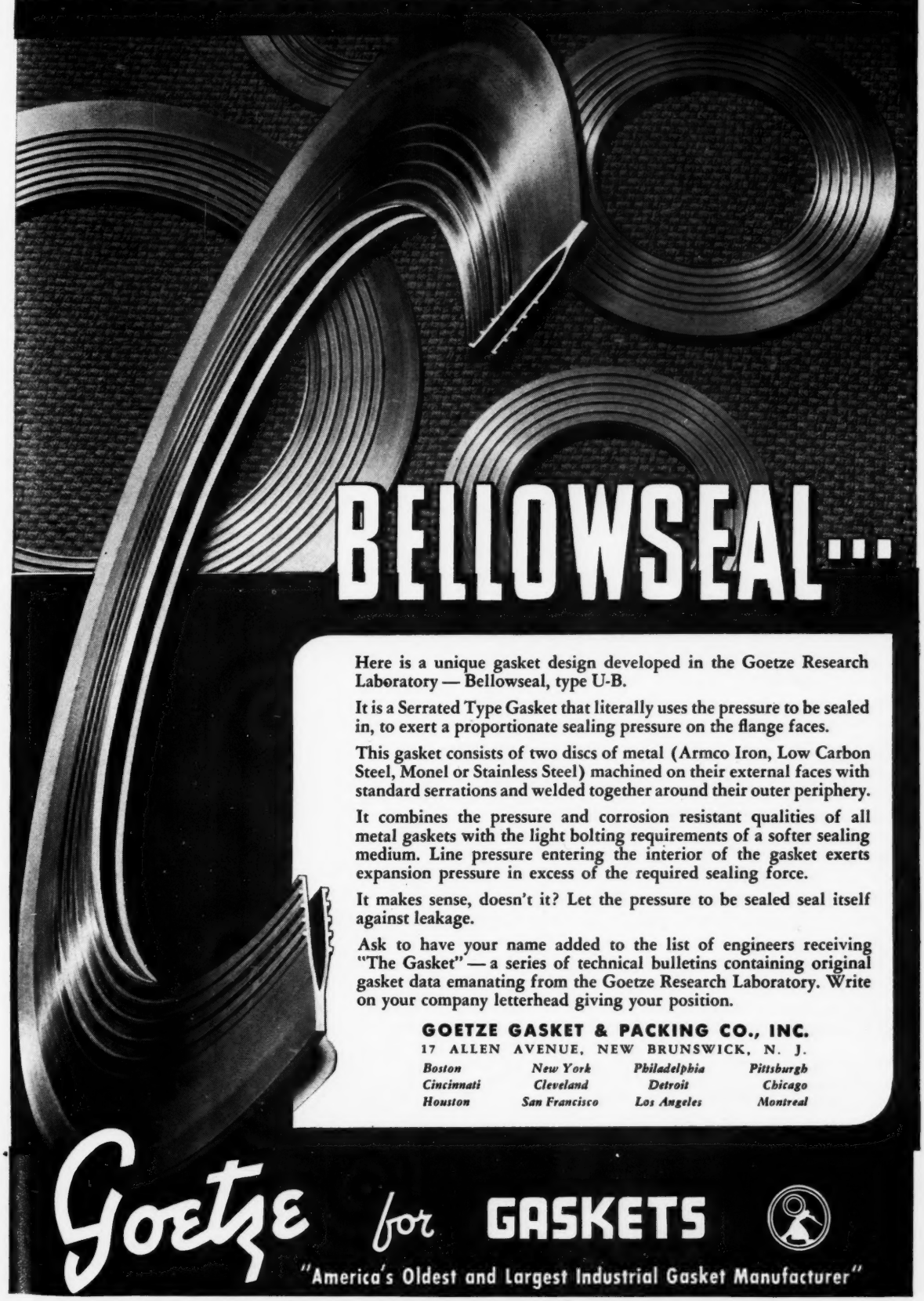
Md., Baltimore—American Can Co., 230 Park Ave., New York, N. Y., plans installation of electric power equipment in new plant at Erdman Ave. and North Point Rd., Baltimore, where large tract of land has been acquired. It will comprise a main one-story building for tin can manufacture and several auxiliary structures, totalling about 20 acres of floor space in all. A power sub-station and boiler house are planned. Project will be carried out in 1946 and is reported to cost close to $6,000,000.

Mass., Somerset—Montaup Electric Co., Fall River, Mass., will begin superstructure soon for addition to steam-electric power plant at Somerset, with installation of equipment for increased output. Stone & Webster Engineering Corp., 49 Federal St., Boston, Mass., is consulting engineer.

Minn., Madison—Light and Power Dept., has plans in progress for expansion and improvements in municipal steam-electric power station, including installation of new turbine-generator, boiler and accessories. Estimates of cost being made. Perkins & McWayne, Paulton Bldg., Sioux Falls, S. D., are consulting engineers.

N. J., Newark—Anheuser-Busch, Inc., 721 Pestlozzi St., Louis, Mo., brewer, plans power house at new brewery on Frekinghuysen Ave., near Evergreen Ave., Newark, where tract of about 18 acres of land was acquired a number of months ago. It will consist of several large multi-story buildings for brew-house, bottling works and other departments. Electric power equipment will be installed. Cost reported close to $15,000,000. Proposed to carry out project during 1946.

MODERN DEVELOPMENTS OF GASKET RESEARCH



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N. Y., Camillus—Carrier Corp., 300 South Geddes St., Syracuse , N. Y., air-conditioning and refrigeration apparatus, plans new plant at Camillus, near Syracuse, comprising a main building for parts production and assembling, and several auxiliary units. Electric power equipment will be installed. A boiler house is planned. Entire project estimated to cost about $2,000,000.

N. C., Gastonia—Gastonia Full-Fashioned Hosiery Co., Gastonia, plans new boiler house in connection with an expansion program at mill. Program will include new plant units for knitting mill, dye house, etc., and is reported to cost over $400,000 with machinery and electric power equipment. Work schedule to begin soon.

N. D., Valley City—Bd. of Directors, State Teachers' College, plans extensions in power plant at institution, with installation of new turbine generating unit and auxiliary equipment. Estimates of cost are being made. Jesse B. Harris Co., Wesley Temple Bldg., Minneapolis, Minn., is consulting engineer.

Ohio, Bellaire—Ohio River Power, Inc., operating subsidiary of Ohio Public Service Co., Hanna Bldg., Cleveland, Ohio, has plans maturing for extensions in power plant at Dilles Bottom, near Bellaire, with installation of new turbine-generator unit, high-pressure boiler and auxiliary equipment. Cost reported close to $2,000,000. Extensions will be made in transmission lines.

Okla., Ponca City—Municipal Water and Light Dept., plans expansion in municipal power plant, with installation of new Diesel engine-generator unit and accessories. Cost about $350,000. Proposed to arrange bond issue in that amount.

Ore., Salem—Sick's Brewing Co., South Commercial and Trade Sts., plans installation of electric power equipment in new additions to plant, consisting of a main one-story building, 145 x 150 ft., and smaller structures. Work will begin soon. Cost reported over $300,000, with machinery. Joseph Wohleb, Chambers Bldg., Olympia, Wash., is architect.

S. C., Charleston—South Carolina Power Co., will begin superstructure soon for proposed new steam-electric generating station on Ashley River, near city, recently referred to in these columns. Installation will include a turbine-generator of 25,000-kva rating, high-pressure boilers and auxiliary equipment. Completion is scheduled in spring of 1947. Cost estimated about $2,500,000, including transmission line extensions. Engineering Dept., Commonwealth & Southern Corp., Alabama Power Bldg., Birmingham, Ala., is engineer.

S. C., Rock Hill—Celanese Corp. of America, 180 Madison Ave., New York, N. Y., cellulose products, rayons, chemicals, etc., plans power house at proposed new cellulose acetate and rayon yarn mill near Rock Hill, where tract of over 1000 acres of land has been acquired. Plants will comprise a number of one and multi-story buildings for each division noted. Electric power equipment will be installed. Cost reported close to $10,000,000.

Tenn., Nashville—Southern States Cooperative, Inc., 2101 East Fort Ave., Baltimore, Md., commercial fertilizers, seed and farm supplies, plans installation of electric power equipment in proposed new plant at Nashville, where site has been secured. It will consist of several one-story buildings. A boiler house is planned. Entire project reported to cost over $400,000.

Texas, Houston—Lloyd A. Fry Roofing Co., 5302 West 66th St., Chicago, Ill., prepared roofing, roofing papers, etc., plans installation of electric power equipment in new branch plant on Houston-Goose Creek Hy., Houston, where tract of about 18 acres of land has been secured. It will comprise a main one-story building, about 150 x 1000 ft., and several auxiliary units. A boiler house is planned. Cost about $500,000. Work will proceed at once. Olsen & Urbain, 9 East Huron St., Chicago, are architects.

Wash., Friday Harbor—Orcas Power & Light Co., Eastsound, Wash., will soon begin work on addition to power plant at Friday Harbor, near Tacoma. Equipment will be installed for increased capacity. W. S. McCrea, Jr., Perkins Bldg., Tacoma, is consulting engineer.

Wash., Spokane—Washington Water Power Co., 825 West Trent Ave., plans new power substation on 14-acre tract of land near city, estimated to cost about $300,000, with transformers, switchgear and auxiliary equipment. Work is scheduled to be carried out early in 1946.

Wis., Beloit—Bd. of Education, V. F. Dawald, superintendent of schools, is considering construction of a boiler house for central heating service for public schools. Estimates of cost will be made soon.

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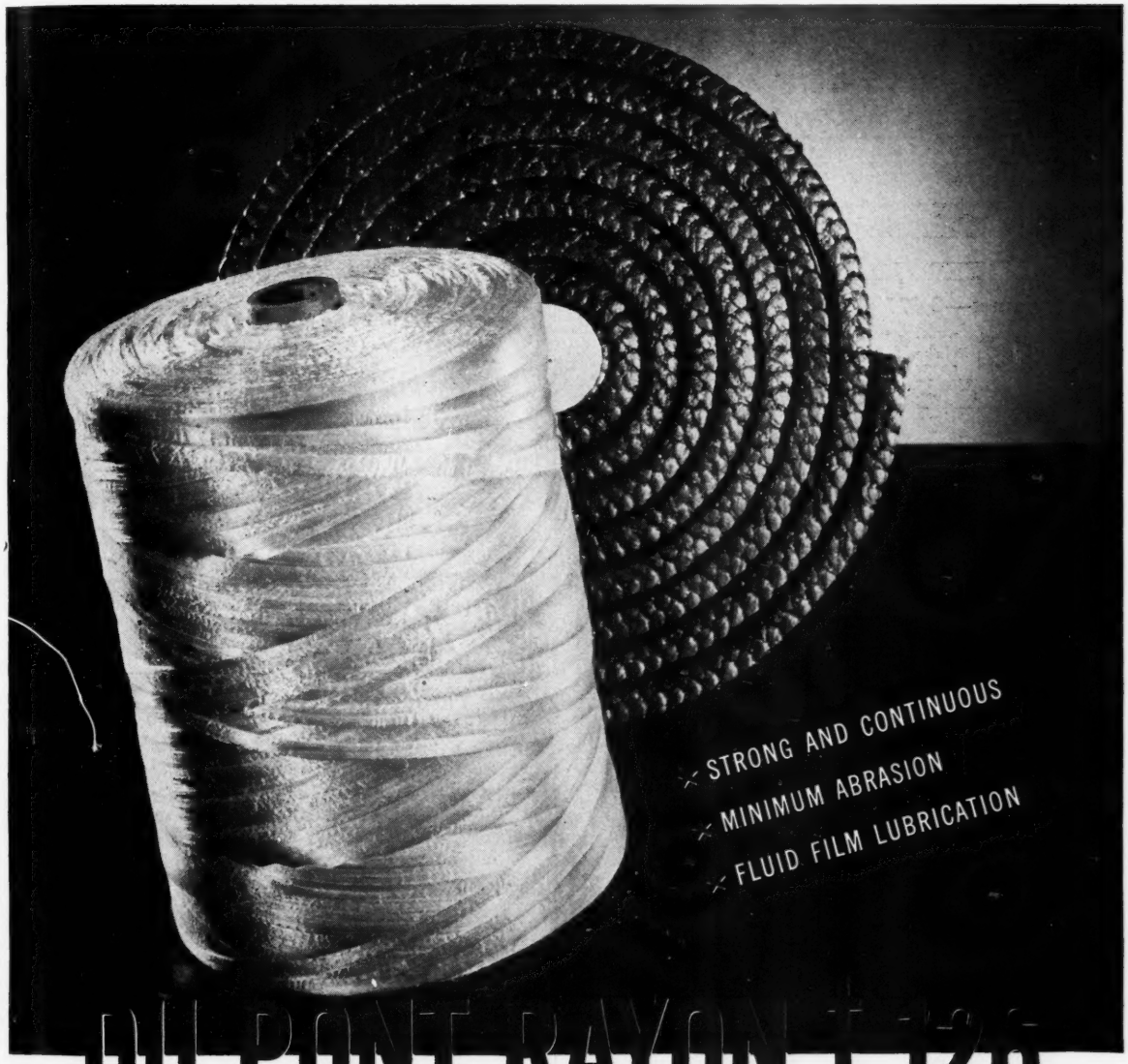

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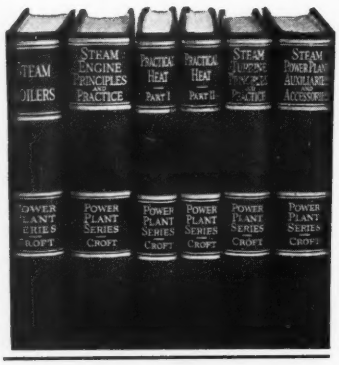
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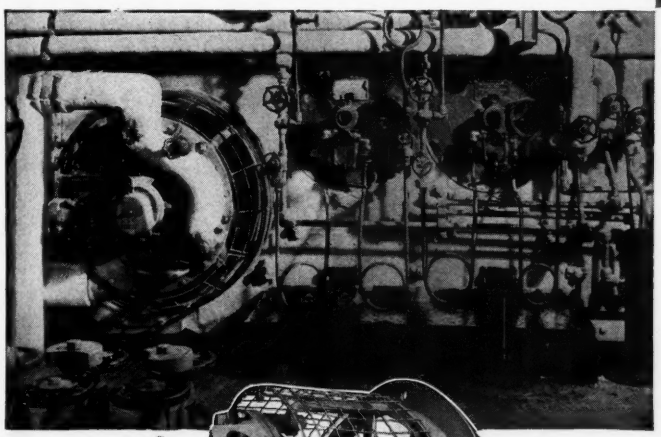

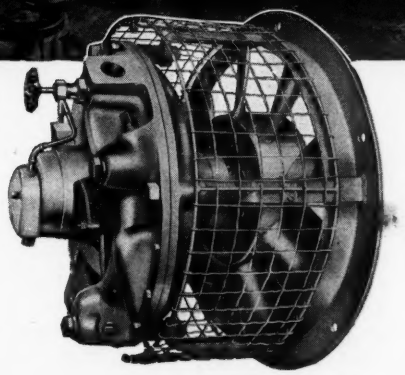

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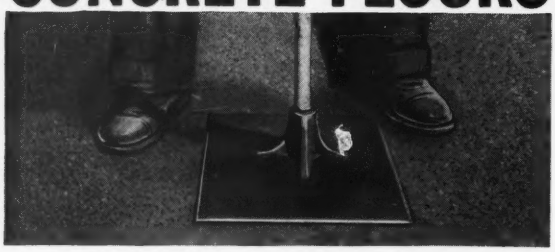

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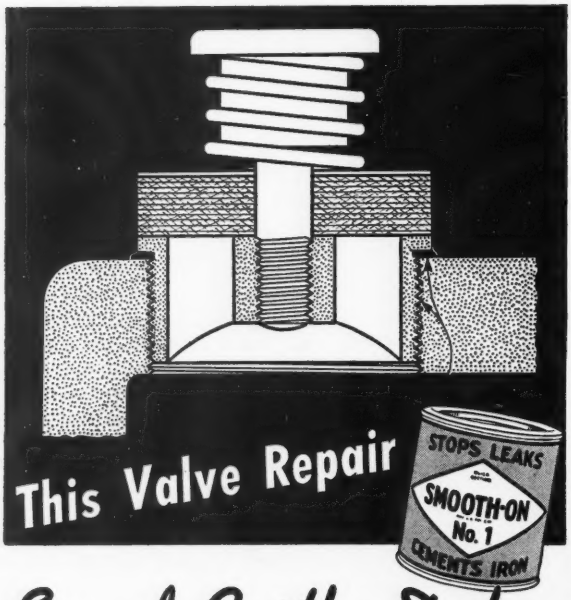

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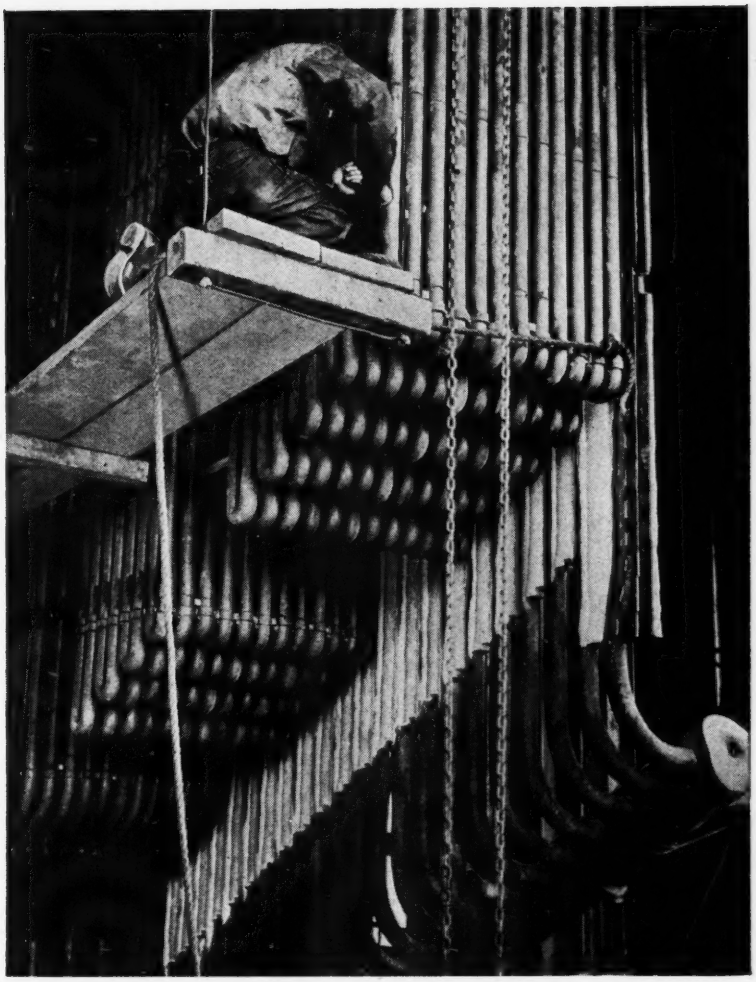

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No one could be more directly concerned with a boiler's *performance* than the boiler *maker*—and a boiler is no better than its tubes. No one, therefore, has a stronger incentive than B&W to produce the best possible boiler tubes . . . because *no* other tube manufacturer is an integral part of an organization that also builds boilers. Every time you buy B&W tubes for *any* steam generating or heat transfer equipment, you get the same high quality, safety, dimensional accuracy and easy workability insisted upon in B&W tubes for all new B&W-built boilers. Besides, you get tubes matched to your specific service conditions without prejudice toward any type or materials because B&W makes BOTH SEAMLESS and WELDED TUBES—all to *one* high standard—for every power plant requirement.

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Non-Buckling* Breechings

Installed in New
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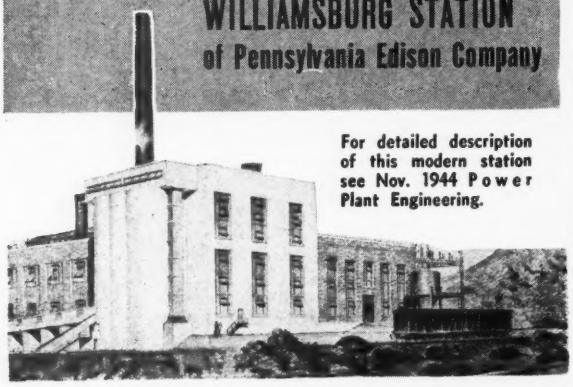

For detailed description of this modern station see Nov. 1944 Power Plant Engineering.

ONCE a company puts in Connery Breechings, Ducts, or Uptakes there's usually a "repeat" order in the offing. When more equipment of this type is required—for new plants or replacements of old equipment—Connery Construction gets the call.

This happened recently up at Williamsburg, Pa., where the Pennsylvania Edison Company installed Connery Breechings, Ducts and Coal Chutes. Engineers for the Company knew the advantages of Connery Expansion-Stiffened Construction, had seen it deliver non-buckling, leakproof and long-lasting service on previous Company jobs; considered it still the outstanding buy.

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NOW READY

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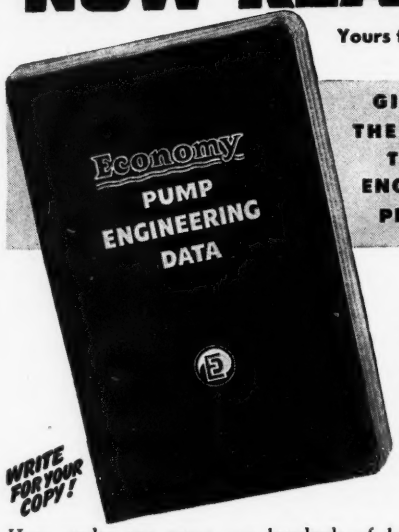

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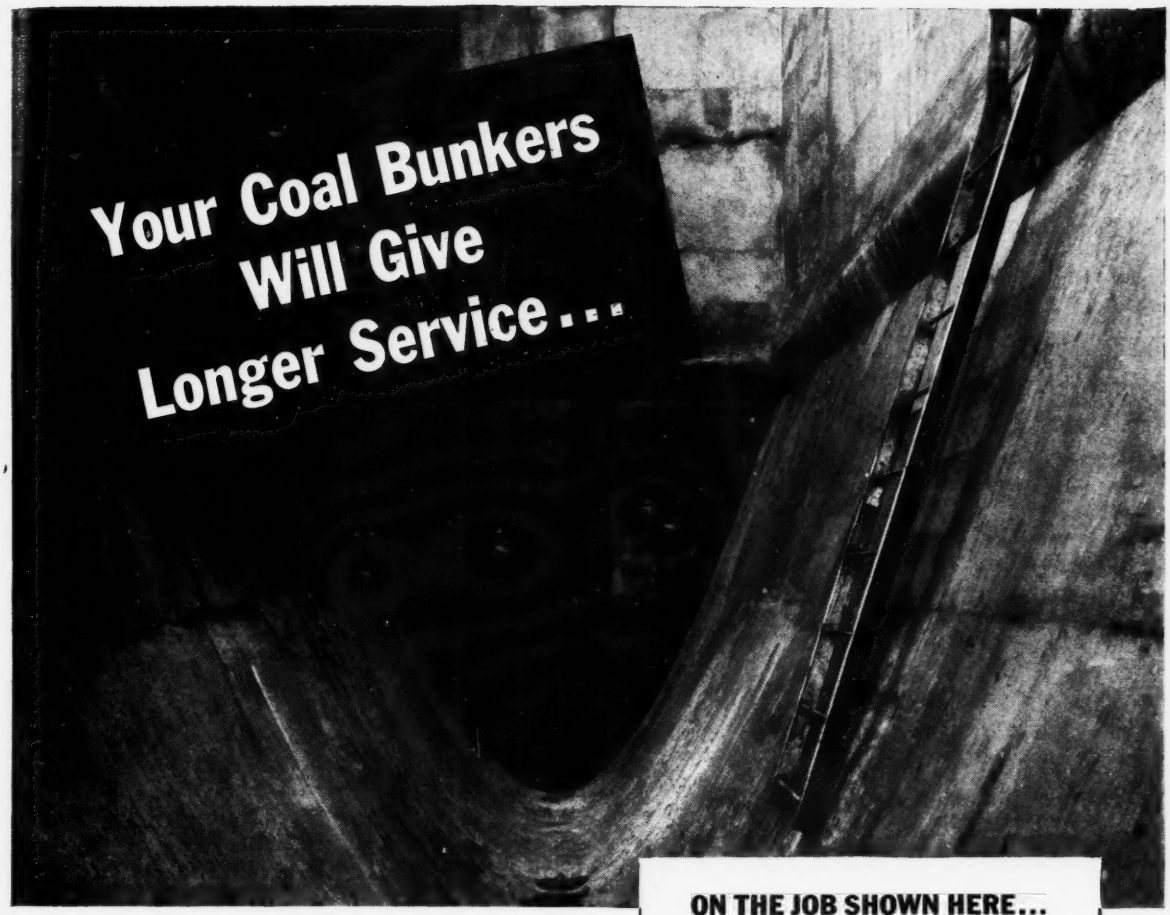

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Protective linings of corrosion-resistant concrete—made with LUMNITE—will increase the life of your coal bunkers. For this super-tough concrete withstands abrasion and resists corrosive action of acid waters.

LUMNITE linings may be plastered over reinforcing mesh (like the one shown in the picture), shot on with a gun or cast in forms. Because LUMNITE is a rapid-hardening cement, the bunker is ready for use 24 hours after the concrete is placed.

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DIMENSIONS OF BUNKER:
32' long x 16' wide x 26' deep.

WIRE MESH:
6 x 6 mesh (#10 wire) spot welded to ¾ inch nuts which were welded to the shell on 12-inch centers.

CONCRETE:
1 part Lumnite to 3½ parts sand and sufficient mixing water to provide a plastic mixture. Concrete is 2" thick.

LUMNITE linings *also protect flues, stacks, cinder-catchers and ash-hoppers from corrosion, abrasion and high temperatures. Write for information on the type of LUMNITE lining to use on your job.*

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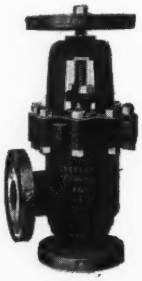
Install this EVERLASTING "Duplex" Boiler Blow-off Valve Unit and you'll get PROMPT, DEPENDABLE valve teamwork . . . and no more blow-off troubles!

This is the SEALING Valve

The EVERLASTING Lever-operated Valve (shown on the LEFT of the Unit) provides QUICK opening and closing. An easy, quarter-turn short-stroke movement of the lever assures full-pipe-size opening with straight-through flow . . . or drop-tight closing — *instantly!* And each opening or closing action regrinds the disc on the seat, maintaining the famous Everlasting drop-tight seal.

The EVERLASTING Wheel-operated Angle Valve (on the RIGHT of the Unit) bears the shock of the blow-off force. It supplies enduring resistance to the erosive action of abrasive solids usually present in boiler blow-off water. No pockets anywhere in this valve for the lodgement of solids. A sturdy long-life team—this EVERLASTING Duplex Valve Unit! And it meets all code requirements for your boiler blow-off service. Built with various features, for pressures to 600 lb., sizes 1½" to 2½". Either valve available separately.



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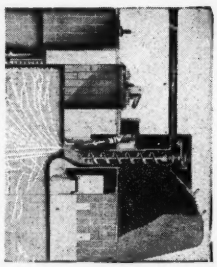
Save with FYR-FEEDER—Burn less coal—Cheaper coal—Local coals—Screenings—Coal Yard Sweepings, wet or dry—WET coal is no handicap.



FYR-FEEDER exclusively employs ← air JET Coal PROPULSION

Fines burn in suspension, larger pieces are spread evenly over grate.

FYR-FEEDER increases boiler capacity—responds instantly to sudden load variations—requires no special skill or experience to operate—thin fuel bed eliminates clinkers—makes fireman's work much easier—no banking losses.

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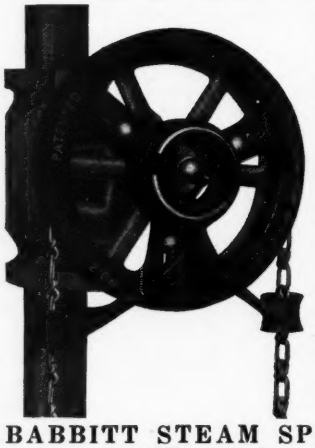

Stop climbing ladders to open and close those "high up" valves. Equip them with Babbitt Sprocket Rims and you can control them quickly and safely from the floor. Babbitt Rims are easily attached and low in cost. They show real savings in time and steam—help guard against accidents. Now is the time to fit your overhead valves with Babbitt Rims. Write today for further information.

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with Chain Guide

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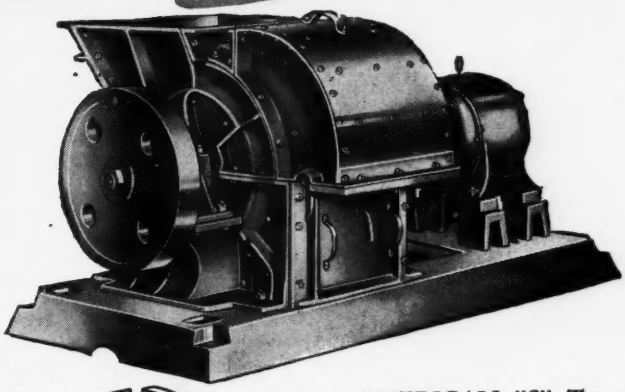
The American Way

After installation of American Rolling Ring Crushers, power plant studies show total cost of crushing coal, including power, labor and depreciation costs, to be, in many cases, less than 1c per ton.



AMERICAN "S" Type RING CRUSHER

Shredder Rings of maganese steel are a patented feature of American Rolling Ring Crushers exclusively. The twenty cutting teeth on the shredder rings revolving at terrific centrifugal force split the coal instead of crushing it, to prevent clogging and minimize unwanted sizes.

Without the use of shear pins or other safety devices, damage from metal contact is entirely eliminated by the deflecting action of the free swinging shredder rings.

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The informative, valuable booklet "Crushing Coal at Less Than 1c Per Ton" will be sent you upon request. Write for it now.

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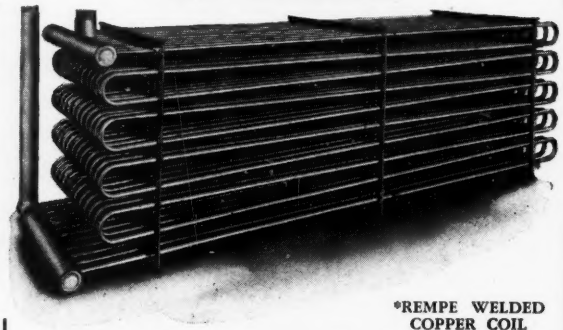

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Copper coils and copper headered assemblies are now being made for heat reclaiming application—engineered and built to meet your particular requirements.

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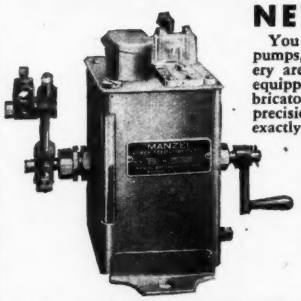

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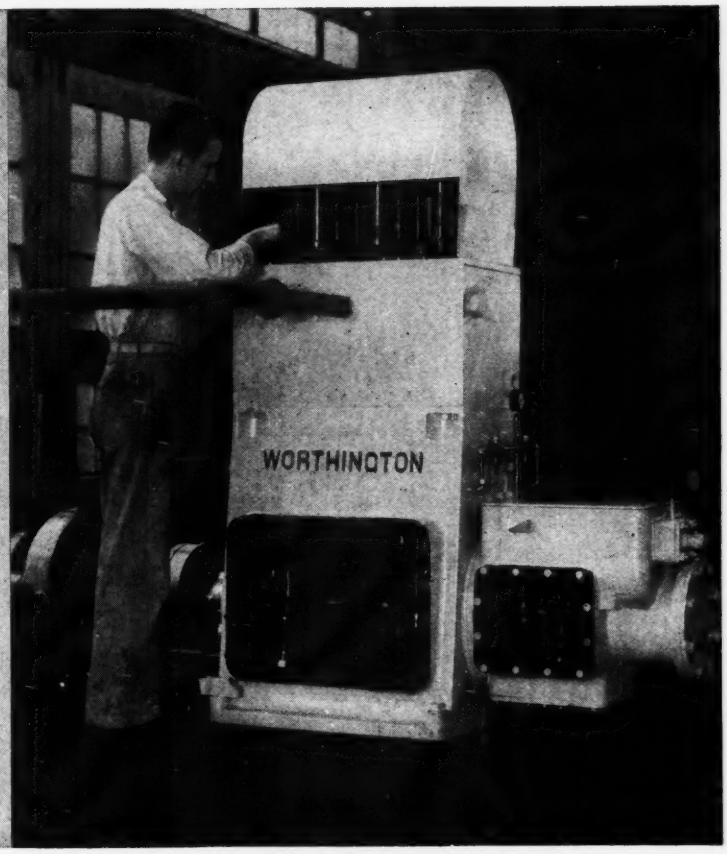
High pressure boiler feed pumps with 0-100% capacity control have constant speed, high efficiency... with distinctive simplicity



Whether the pressure is 500 PSI or 5000 PSI, the Worthington Automatic VARIFLO Triplex Power Pump is your best selection for a high pressure feed pump for boilers and desuperheaters.

The photograph shows the easy accessibility of the stuffing boxes on top of the cylinder (an exclusive Worthington design), making routine attention easy . . . The first Worthington VARIFLO in service taken down after 12 months of continuous service, showed tool marks still evident on the stroke-changing elements. . . . The features listed below mean reduced operating costs, uninterrupted and continuous service.

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8. Crankshaft is at the bottom, engine-style — loads are transmitted and supported close to foundation.
9. Running parts are fully enclosed.

Bulletin W-414-B50 on Worthington VARIFLO Power Pumps is "must" reading for all engineers interested in efficient boiler feed service. Write for it today. *Worthington Pump and Machinery Corporation, Harrison, N. J.*

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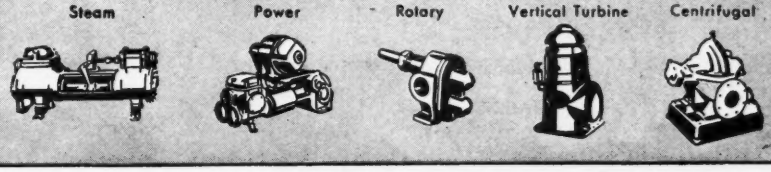

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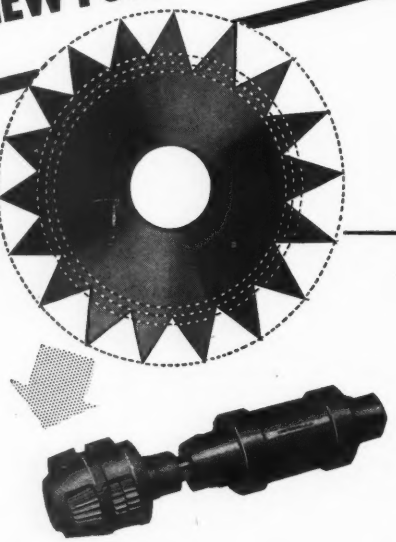

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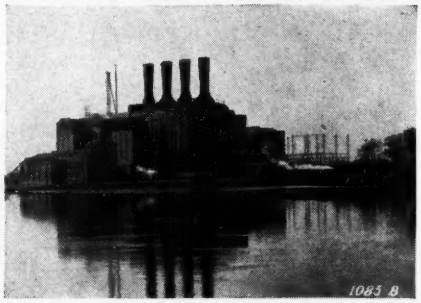

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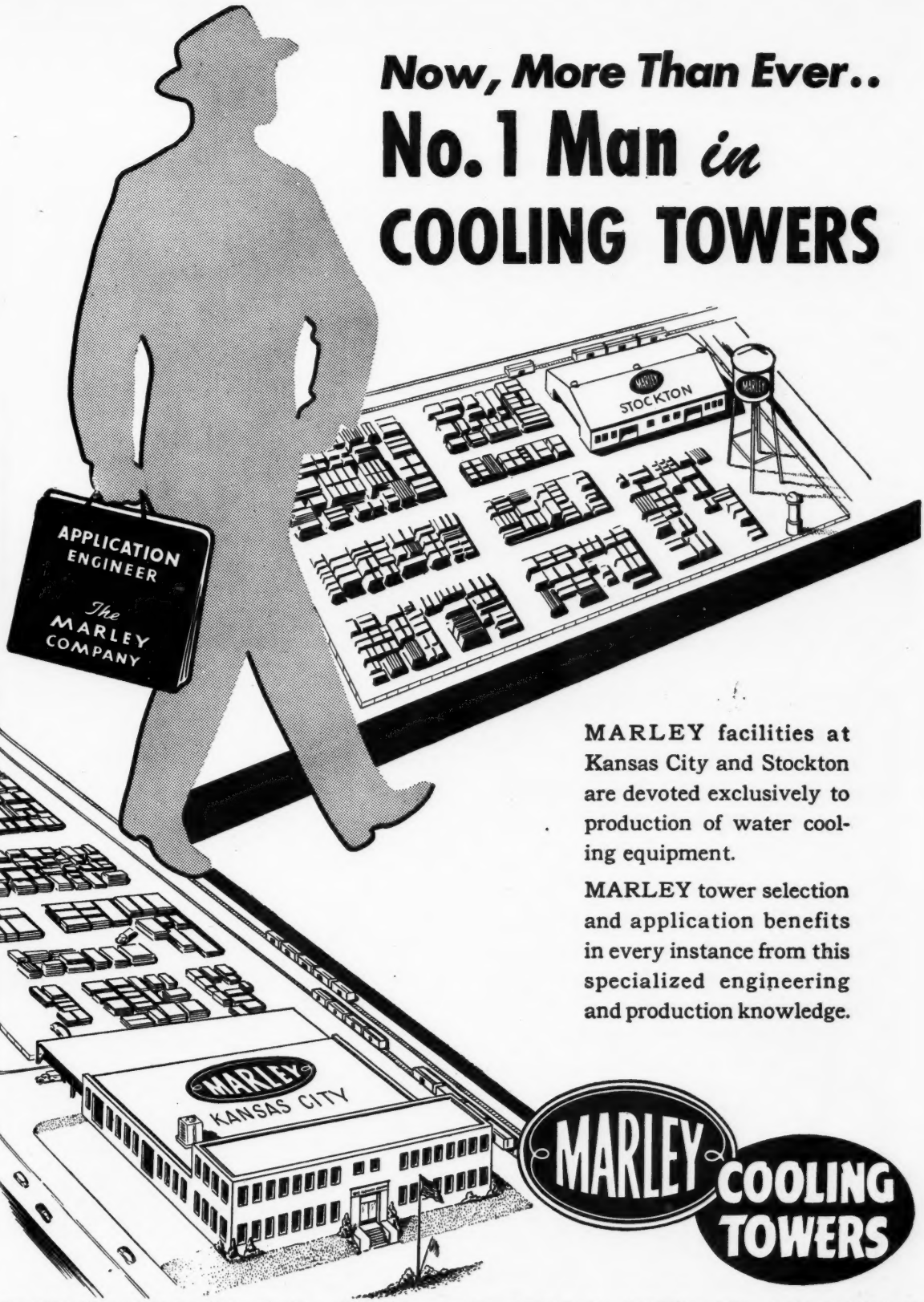

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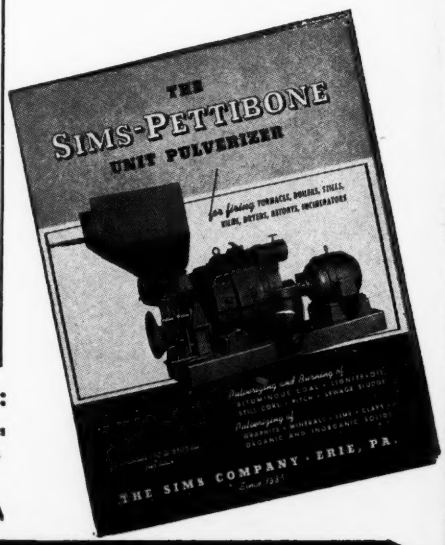

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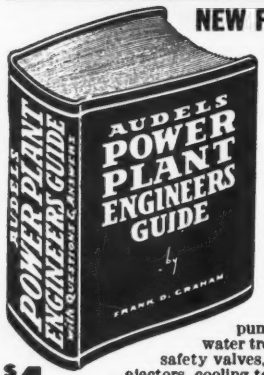

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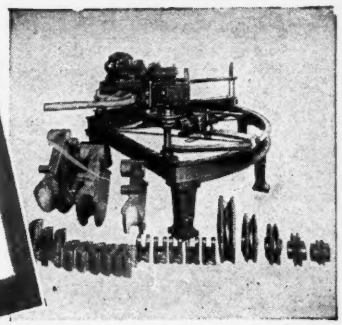

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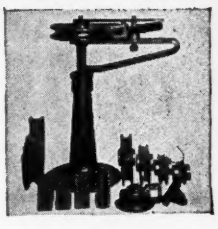

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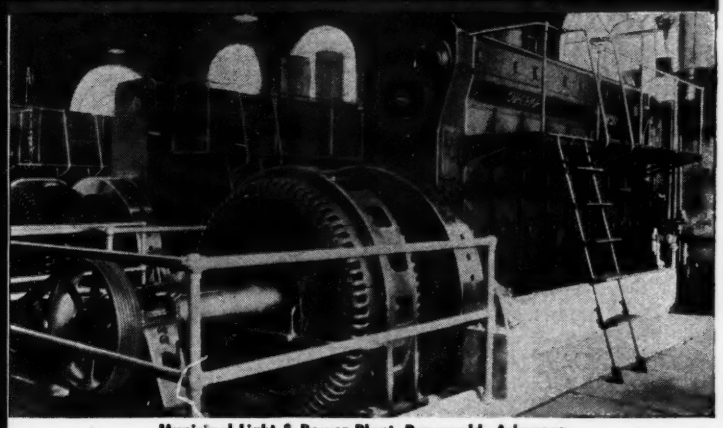
There are Values in

Superior DIESELS

. . . . that only performance can reveal



Municipal Light & Power Plant, Paragould, Arkansas

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MARINE • STATIONARY • LOCOMOTIVE

Superior ENGINES
Division of
THE NATIONAL SUPPLY CO.
Plant and General Sales Office: Springfield, Ohio

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PUSH-PULL CONTROLS

Solve problems in . . .

PRECISION DETOURS VIBRATION

Are you taking advantage of the most advanced design methods in handling your remote control problems?

Simmonds Push-Pull Controls, developed to meet exacting aircraft standards, are being increasingly specified by industrial engineers in many fields. More than half a million Simmonds controls are today giving rugged, trouble-free service in installations that require the ultimate in accuracy—eliminating awkward pulley-and-cable and rod-and-bellcrank set-ups. Especially successful in solving problems involving vibration and difficult contours. A wide variety of accessories and fittings make Simmonds controls adaptable to many purposes.

Let Simmonds engineers help solve your remote control problems. There is no obligation.

Send Your Control Problems to Simmonds Control Headquarters

Simmonds AEROCESSORIES, INC.

Simmonds PRODUCTS INC.

30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.

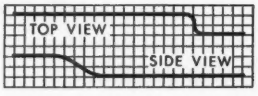
Branch Offices: Dayton, Ohio • Glendale, California • Montreal, Canada

Let Simmonds Analyze Your Control Problem

Simply submit the basic requirements, as follows:

- **What does the control operate?**
- **LOAD: Compression (lbs.) Tension (lbs.)**
- **VIBRATION CHARACTERISTICS**
- **TEMPERATURE CONDITIONS**
- **PRESENT SYSTEM**
- **FLEXIBLE OR RIGID HOUSING?**

Make sketches of top and side views of installation. Use regular graph paper and indicate unit of measure.



OTHER SIMMONDS PRODUCTS:

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Protect Your Boilers Against Pitting, Corrosion and Scale with

Magic BOILER PRESERVATIVE

• This modern boiler preservative contains colloids that possess adsorptive properties. It holds all precipitates in suspension, while at the same time establishing a protective colloidal film on the metal to arrest pitting and corrosion. Its action is simple, safe, sure; helps your boiler produce more steam.

Write for Descriptive Bulletin

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Established 1904

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OF CALIFORNIA
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FOR SALE
USED, OPERATING CONDITION

2. 62½ K. W. Chuse 4 valve, balanced slide valve, steam engines 125# pressure 5# back. Direct connected to Westinghouse D. C. Generators, 3 wire 115/230 volts.
1. 37½ K. W. Chuse balanced single valve, steam engine 125# press. 5# back. Direct connected to Westinghouse D. C. Generator, 3 wire 115/230 volts.

Complete with separators, balancing coils and gen. panels (few switches and instruments missing). Priced to sell. Write.

HUNTINGTON HOTEL CO.
c/o Chief Engineer, Pasadena, Calif.

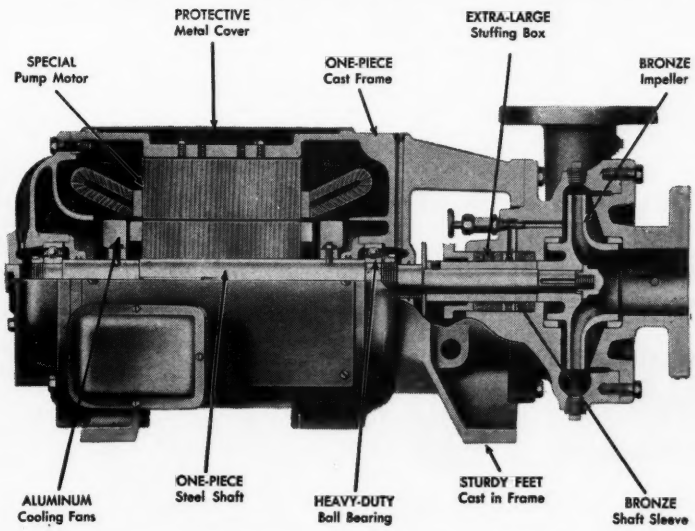
FOR SALE

Approximately twenty used model H 250-pound per hour capacity Fairbanks Morse Stokers. These Stokers have been used around two years and are offered subject to prior sale at approximately one third their original cost. If interested write or wire

TENNESEE EASTMAN CORP.
Kingsport, Tennessee

X-Ray View

Shows Why A-C's Smooth-Running Electrifugal Pump is the Finest of its Kind!

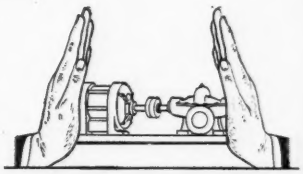


TOP QUALITY and extra value — that's what A-C's Electrifugal Pump gives you in terms of performance and economy! X-ray view above shows how Allis-Chalmers engineering has magically combined pump-and-motor into a single compact unit — which takes less space, gives you smooth operation with maximum protection against dangers of abnormal wear, leakage, corrosion, vibration! Consider these outstanding features: One-piece frame saves 33% in space; one shaft for pump-and-motor assures alignment; splash-proof motor is specially designed for pumping at low power cost. For further details on this great pump, call your nearby A-C office, or write ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

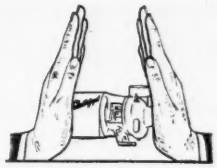
HEAR THE BOSTON SYMPHONY: *Saturday, American Broadcasting Co.*

A 1924

SQUEEZE PLAY CUTS SPACE 33%!



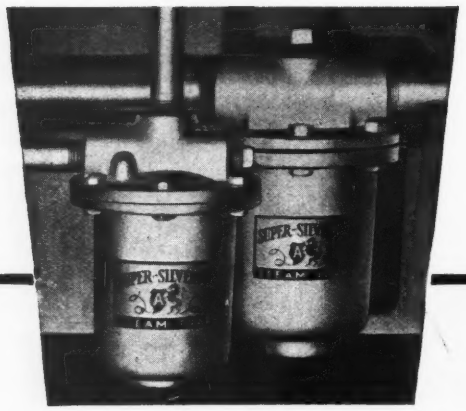
PROBLEM: Here is conventional pump and motor. How can we couple them together *better*—to save space, cut danger of misalignment, harmful vibration?



SOLUTION: We design a new kind of pumping unit—the one and only "Electrifugal" Pump! Motor and pump are now on one shaft—which cuts space 33%, assures alignment and smooth operation. No wonder "Electrifugals" give you more pumping power for your money!

SEA-BLUE BEAUTY: Modern design of Electrifugal Pump looks well on jobs anywhere! Capacities from 15 to 1600 gpm—heads up to 500 feet.

ALLIS-CHALMERS *Electrifugal* PUMPS



Simplified Piping
BOTH WAYS

Anderson Super-Silvertop Steam Traps, in one style and in all sizes, give you simplified steam trap piping *both* ways—as an elbow and straight-in-line. Simplified piping means lowest installation costs for inverted bucket traps. Described fully in "How to Choose a Steam Trap"—send for your free copy.

THE V. D. ANDERSON COMPANY
1939 West 96th Street • Cleveland 2, Ohio

SUPER-SILVERTOP STEAM TRAPS

FOR SALE

3—Used Riley-Jones, heavy duty, under feed stokers, single retort, side dump type.
Width between side walls 6'. Length from inside front wall face to face of bridge wall 6'4½".
Horizontally projected grate area 38.2 sq. ft.
Front wall thickness 18".
Equipped with Riley-Jones hydraulic drive consisting of a hydraulic cylinder with straight line ram feed controlled by a valve to vary intervals between ram stokes.
The power unit consists of motor, fan, oil pump, and tank, is separate and may be located where convenient.
Each stoker is equipped with the following; front plates ¾" cast iron with 1¼" beading, 57" high by necessary width, 2 fire doors refractory lined with peep hole, 2 ash pit doors, 1 air chamber.
These three used stokers are in very good condition. We paid for the 3 used stokers $4707 and are willing to take 50% of this cost.

1—New Riley-Jones, heavy duty, under feed stoker, single retort, side dump type.
Width between side walls 7'0".
Length from inside front wall to face of bridge wall 9'4½".
Horizontally projected grate area 65.6 sq. ft.
Front wall thickness 18".
This stoker equipped with steam drive consisting of lagged steam cylinder with straight line ram feed on retort.
Stoker equipped with front plate ¾" cast iron with 1¼" beading, 6" high by necessary width, with fire and ash pit doors. We paid for this large new stoker $2751. Will sell this stoker for 60% of its price.

All stokers F.O.B. Watertown. Electrical equipment necessary to operate these stokers may be had with the units. We will sell units separately.

PRINCETON KNITTING MILLS, INC.
WATERTOWN, CONN.

Want Practical Answers to your FUEL BURNING Problems?

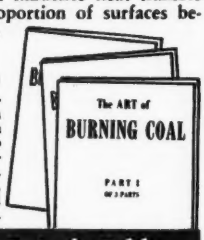
Now is the time for plant managers to plan for cheaper steam . . . for engineers to gain the boiler operation know-how that paves the way to bigger opportunities and earnings. Note how these new books provide basic answers to your many fuel-burning problems.

THE ART OF BURNING COAL (3 vol., 200 pg., $15.00) brings you latest data on Combustion Performance; Hints on Burning All Types of Coal, How to Cut Down Fly Ash, How Stokers Can Best Handle Various Degrees of Air Preheat; answers to 101 other questions faced by plant engineers and owners.

HEAT TRANSFER IN BOILERS AND WATER WALLS (90 pg. 33 illus., $3.00) names and defines all factors that influence heat transfer in boilers, shows how to figure best proportion of surfaces between water walls and tube banks; contains many charts based on test data.

See This Complete Course on Combustion

These easy-to-understand books give you a complete, advanced course in combustion and steam generating methods. Knowledge gained through "The Art of Burning Coal" makes it easy to reduce your coal bills. This course is prepared for plant managers and chief engineers. Ask for free descriptive bulletins, or better still, fill in and mail the coupon below and we'll send the books to you for 10 days examination.



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for alkaline, sulphurous and leakage protection of tanks, stacks & breechings has been time tested by industry. One of the world's largest packing plants lined several hundred tanks with PLASTIKSTEEL during 1944. Repeat order received September, 1945.

Picture at right showing 200,000 gallon R. tank being lined with PLASTIKSTEEL.

PLASTIC STEEL SERVICE
210 California Street San Francisco 11, Calif.

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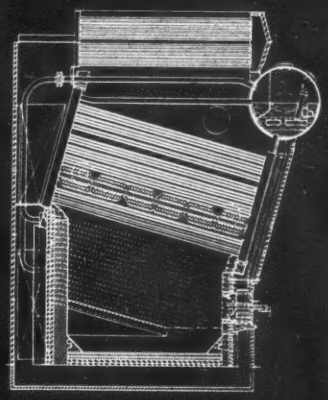
Please send reservations and copy on or before **10th** of preceding month; complete plates can be accepted up to **17th.** Be an "early bird"—help us mail issues on time. . . . . .

is YOUR Boiler-Water Treatment Complete?

No. 1 in a series of advertisements on the requirements for the COMPLETE conditioning of boiler water.

here's what COMPLETE boiler-water treatment MUST include:



1. SOUND CHEMICAL TREATMENT
2. A GOOD ORGANIC COAGULANT
3. SIMPLE BUT SCIENTIFIC CONTROL
4. COMPETENT SERVICE and INSTRUCTION

The most able engineer cannot be expected to know all the "ins and outs" of Boiler-Water Chemistry — but any engineer can make certain that boilers are free from scale, corrosion, wet steam and waste by using a system of boiler-water conditioning that meets THESE FOUR fundamental requirements.

Settle down to sound operation with AMEROID — the COMPLETE Boiler-Water Treatment.

Incomplete boiler-water treatment can be VERY costly . . . if you are not sure that your system of boiler-water treatment is COMPLETE, talk it over with the DREW Man—there's no obligation!

AMEROID

The COMPLETE Boiler-Water Treatment

E. F. DREW & CO., Inc.

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Standard Lines

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Should a special type of valve be required, Chapman engineers will be glad to help you develop it.

THE

CHAPMAN

VALVE MANUFACTURING CO.

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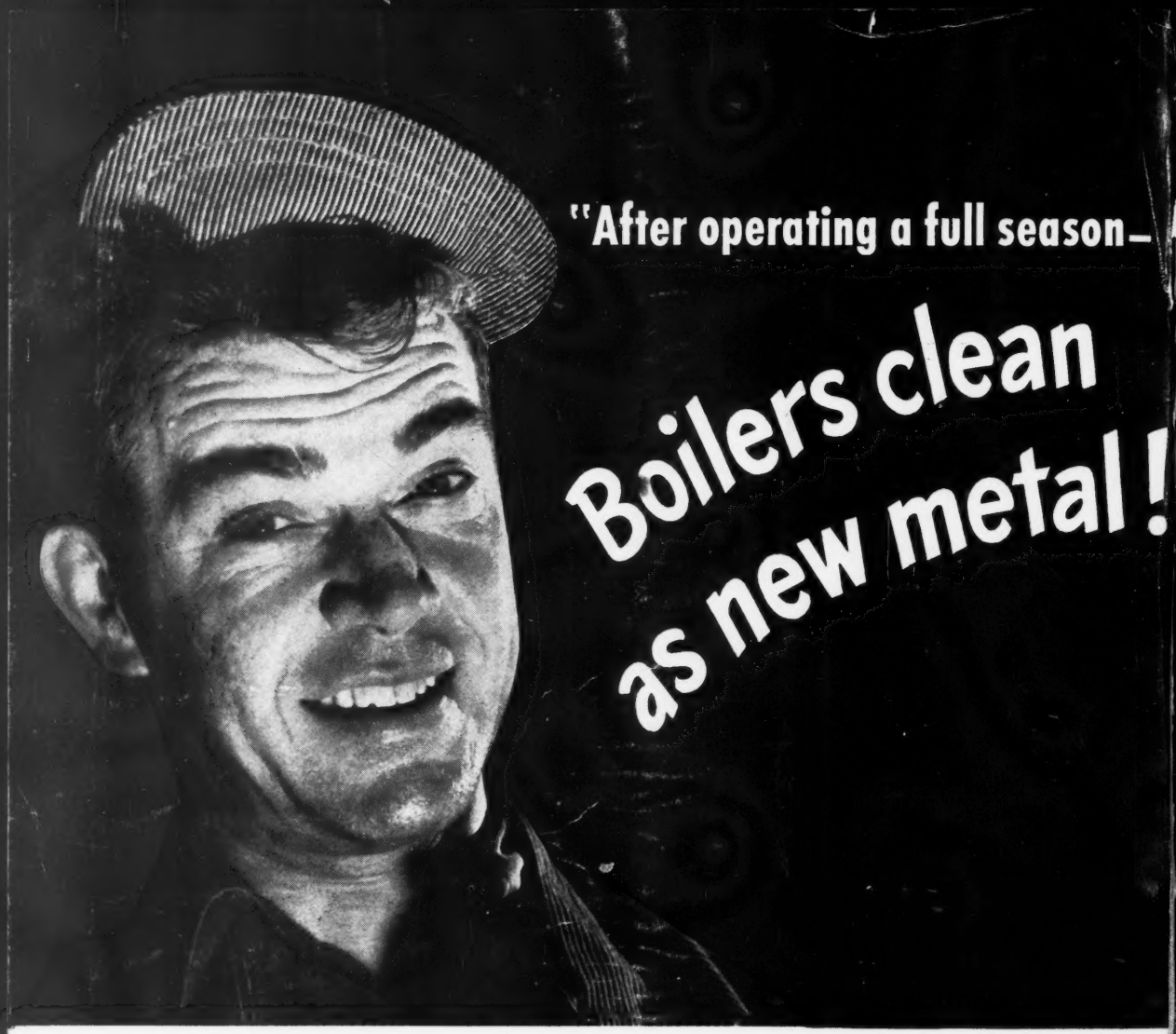

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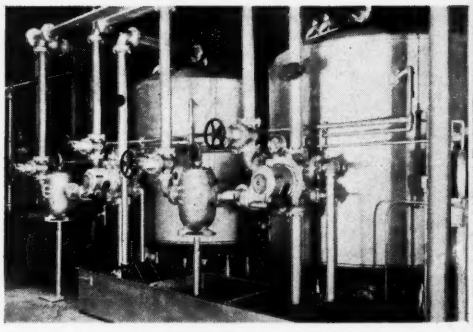
Permutit* removes these impurities *before the water enters boilers,* preventing shutdowns and destruction of equipment. World's largest manufacturers of water conditioning equipment, Permutit provides *every* process for controlling water quality.

Take no chances . . . keep *your* boilers "clean as new metal" with Permutit equipment. Write about any water problem that you may have to The Permutit Company, Dept. A1, 330 West 42nd Street, New York 18, N. Y.



PERMUTIT ZEO-KARB* H WATER CONDITIONER removes both hardness and bicarbonates from water. Effluent contains no incrustants, is reduced in total solids and alkalinity. Alkalinity can be adjusted by mixing effluents from a Zeo-Karb H unit and a sodium zeolite unit.

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PERMUTIT

Manufacturers of ALL types of water treatment equipment

It's good business to begin with Good Water

WATER CONDITIONING HEADQUARTERS